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(71) Applicant: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
Kadoma-shi, Osaka 571-8501 (JP)

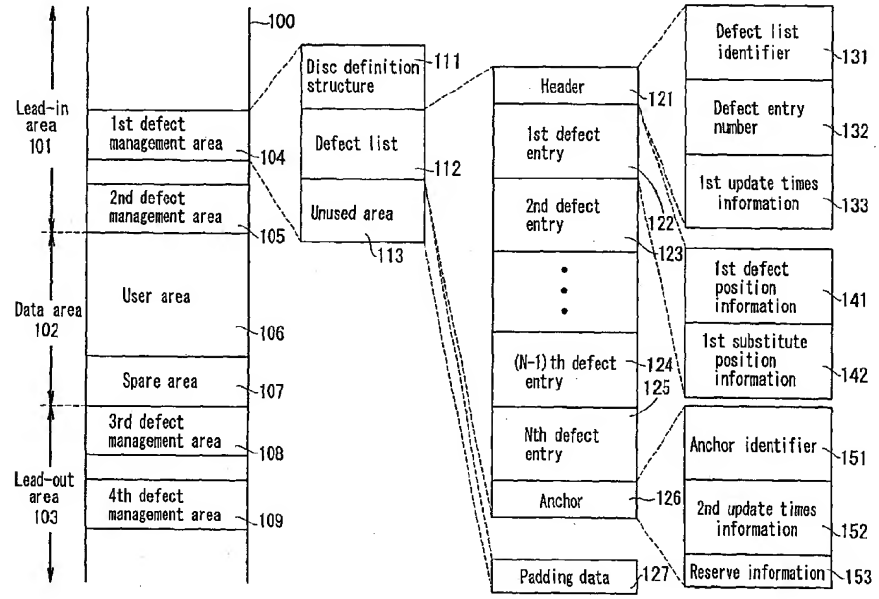
(72) Inventors:
- **Takahashi, Yoshihisa**
  Osaka-shi, Osaka 532-0022 (JP)
- **Ito, Motoshi**
  Osaka-shi, Osaka 536-0001 (JP)
- **Ueda, Hiroshi**
  Nara 639-0223 (JP)

(74) Representative: **Balsters, Robert et al**
Novagraaf International S.A.
25, avenue du Pailly
1220 Les Avanchets - Geneva (CH)

(54) Information recording medium, recording and reproduction apparatus and method

(57) An information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor. The header, the N number of defect entries, and the anchor are located in this order. The header includes a defect list identifier for identifying the defect list, first update times information, and a defect entry number representing the number of the defect entries. The anchor includes an anchor identifier for identifying the anchor, and second update times information.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION:

[0001] The present invention relates to an information recording medium, a recording apparatus, a reproduction apparatus, a recording method, and a reproduction method, providing improved information reliability. More specifically, the present invention relates to an information recording medium, a recording apparatus, a reproduction apparatus, a recording method, and a reproduction method, allowing for updating of a defect list having a size of 2ECC (Error Correction Code) or larger and deletion of a defect entry.

2. DESCRIPTION OF THE RELATED ART:

[0002] Recently, large capacity replaceable information recording media and disc drive apparatuses for driving such information recording media are becoming more and more popular. As large capacity replaceable information recording media, optical discs such as, for example, DVDs (Digital Versatile Discs) are well known. A disc drive apparatus irradiates an optical disc with laser light and thus forms very small pits in the optical disc so as to record information. The disc drive apparatus also irradiates an optical disc with laser light and reproduces a change in the reflectance caused by the pits as information. Large capacity replaceable information recording media are suitable to a disc drive apparatus performing information recording and reproduction in this manner. However, since the optical discs are replaceable, a defect caused by dust or scratches may exist on a recording surface thereof.

[0003] In order to guarantee the reliability of information recorded or reproduced by the disc drive apparatus, it is necessary to perform defect management of managing a defect existing on the optical disc. The defect management used for a conventional disc drive apparatus is described in the physical standards of DVD-RAM (e.g., "DVD Specifications for Rewritable Disc (DVD-RAM) Part 1 PHYSICAL SPECIFICATIONS Version 2.0"; hereinafter, referred to as the "DVD-RAM Standards"). Chapter 5 of the DVD-RAM Standards includes a description on the layout of a disc.

[0004] Figure **12** shows a data structure of an information recording medium **1200** according to the DVD-RAM Standards.

[0005] The information recording medium **1200** includes a lead-in area **1201** for recording information regarding the disc, a data area **1202** for recording user data, and a lead-out area **1203** showing the termination position of the user data.

[0006] The lead-in area **1201** includes DMA1 (Defect Management Area) and DMA2 for recording defect management information used for managing a defect area existing in the data area **1202**, and reserved areas **1204** and **1205** for future expansion.

[0007] The data area **1202** includes a user area **1206** for recording user data and a spare area **1207**. When there is a defect area in the user area **1206**, the user data which is to be recorded in the defect area is recorded in the spare area **1207** instead of a portion of the user area **1206** corresponding to the defect area.

[0008] The lead-out area **1203** includes DMA3 and DMA4 for recording defect management information used for managing a defect area existing in the data area **1202**, and reserved areas **1208** and **1209** for future expansion, like the lead-in area **1201.**

[0009] DMA1 through DMA4 have the same defect management information recorded in multiplex. The reason for this is that the information recorded in DMA1 through DMA4 cannot be a target of defect management. Even if some of DMA1 through DMA4 have a defect area and the information recorded on the information recording medium cannot be reproduced, as long as at least one of DMA1 through DMA4 is defect-free, the defect management information recorded in that area can be normally reproduced. Accordingly, loss of user data is prevented, which improves reliability.

[0010] DMA1 includes a DDS (Data Definition Structure) **1210,** a PDL (primary Defect List) **1211,** and an SDL (Secondary Defect List) **1212**.

[0011] The DDS **1210** includes information regarding a partition defining the PDL **1211** and the SDL **1212**.

[0012] The PDL **1211** is position information (list) of defect areas (for example, defect sectors) detected in the user area **1206** and the spare area **1207** at the time of shipping of the information recording medium, i.e., at the time of initialization of the information recording medium. This list basically does not change unless the information recording medium is subjected to physical formatting.

[0013] According to the DVD-RAM Standards, the total size of the DDS **1210** and the PDL **1211** fits in one ECC (Error Correction Code) block. The size of the SDL **1212** also fits in one ECC block. An ECC block is a unit of error correction in DVD-RAM, and has a size of 32 kbytes in 16 sectors (each sector has a size of 2 kbytes). This size of one ECC block will be referred to as "1ECC size".

[0014] Figure **13** shows a detailed data structure of the SDL **1212**.

[0015] Unlike the PDL **1211**, the SDL **1212** is information (list) which changes when a defect area (for example, defect sector) is detected during recording or reproduction. When a defect area is detected, the SDL **1212** is written in each of DMA1 through DMA4 at a timing appropriate to the disc drive apparatus used.

[0016] The SDL **1212** includes a header **1301**, a first defect entry **1302,** a second defect entry **1303,** ..., an Nth defect entry **1304**, and an unused area **1305**.

[0017] The header **1301** includes, for example, an identifier which represents that the area is the SDL

1212, the total number of defect entries (N in the case of Figure **13**), and the number of times the SDL **1212** has been updated.

[0018] The first defect entry **1302** includes first defect position information **1306** showing the position of a defect area existing in the user area **1206** and first substitute position information **1307** showing the position of a part of the spare area **1207** in which the user data has been recorded instead of the defect area (for example, a substitute sector). The second defect entry **1303** includes second defect position information and second substitute position information. The Nth defect entry includes Nth defect position information and Nth substitute position information. Each of the defect position information and the substitute position information is generally a sector number.

[0019] The unused area **1305** exists in the case where the total size of the header **1301** and the first through Nth defect entries **1302** through **1304** is less than 1ECC size. In this case, padding data (for example, 0) which is meaningless information is recorded in the unused area **1305**.

[0020] There is a risk that while the disc drive apparatus is writing the SDL **1212** in DMA1 through DMA4 of the information recording medium **1200,** the power of the disc drive apparatus may be turned off and processing may be interrupted. In such a case, the disc drive apparatus determines the update result of the defect management areas (DMA1 through DMA4) by the following procedure.

(1) Error correction is performed on the SDL **1212** having 1ECC size. When the error correction is accurately performed, the SDL **1212** is determined to have been updated normally.

(2) The step of (1) is performed on all the SDLs included in DMA1 through DMA4.

(3) Regarding all the SDLs determined to have been updated normally in step (2), the numbers of updates of the SDLs included in the header are compared with one another. The SDL having the largest number of updates is determined to be the correct SDL (latest SDL).

[0021] As described above, when the size of the SDL **1212** is 1ECC size, the determination of the correct SDL can be performed accurately even when the power of the disc drive apparatus is turned off. Thus, the reliability of user data is guaranteed with no user data being lost.

[0022] Recently, as the amount of information to be recorded on information recording media is increased, high density recording technology and large capacity technology have remarkably improved. For example, using blue lasers, information recording media having a larger capacity than that of conventional optical discs are now under development. Since such an information recording medium allows a larger capacity of information to be recorded thereon, the size of the SDL is larger than 1ECC size. As long as the size of the SDL is 1ECC size or smaller as according to the DVD-RAM Standards, no problem arises. When the size of the SDL exceeds 1ECC size, the following problems occur. In the following case, the size of the SDL is assumed to be 4ECC size.

[0023] It is assumed that the following occurs to one DMA (for example, DMA1) as a result of the size of the SDL becoming 4ECC size instead of the conventional 1ECC size.

- The header is completely updated.
- The SDL is updated up to 2ECC blocks, and the power of the disc drive apparatus is turned off exactly when the third ECC block is starting to be updated.

[0024] In this case, according to the conventional method of determining the SDL update result, error correction in units of 1ECC is normally performed. Comparing the number of updates of the SDL in DMA1 with that of the SDLs in DMA2 through DMA4, the number of updates of the SDL in DMA1 is maximum. Therefore, although the updating of the SDL in DMA1 fails in the middle, the SDL in DMA1 is erroneously determined to be the normal, latest SDL.

[0025] One solution proposed to solve this problem is to add a header for each ECC block of the SDL having 4ECC size. Each header includes, for example, an identifier which represents that the area is the SDL, the total number of defect entries, and the number of updates of the SDL.

[0026] Figure **14** shows a data structure of an SDL **1400** having 4ECC size.

[0027] The SDL **1400** includes a first ECC block **1401**, a second ECC block **1402**, a third ECC block **1403**, and a fourth ECC block **1404**.

[0028] The first ECC block **1401** includes a header **1405**, a first defect entry **1406,** a second defect entry **1407,** ..., an (M-1)th defect entry **1408,** and an Mth defect entry **1409.**

[0029] The second ECC block **1402** includes a header **1410**, an (M+1)th defect entry **1411**, ..., an Nth defect entry **1412,** and an unused area **1413**.

[0030] The third ECC block **1403** includes a header **1414** and an unused area **1415**.

[0031] The fourth ECC block **1404** includes a header **1416** and an unused area **1417**.

[0032] The headers **1405**, **1410**, **1414** and **1416** each include, for example, an identifier which represents that the area is the SDL, the total number of defect entries, and the number of updates of the SDL. The first through Nth defect entries **1406** through **1409, 1411** and **1412** each include defect position information and substitute position information. In the unused areas **1413**, **1415**

and **1417**, padding data (for example, 0) which is meaningless information is recorded.

[0033] In this case, the disc drive apparatus determines the update result of the defect management areas (DMA1 through DMA4) by the following procedure.

(1) For the SDL **1400** having 4ECC size, error correction is performed on the first ECC block **1401**. When the error correction is accurately performed, the first ECC block **1401** is determined to have been updated normally. This step is performed on the second through fourth ECC blocks **1402** through **1404** in the SDL **1400**. When the error correction on the first through fourth ECC blocks **1401** through **1404** is accurately performed, the step (2) is performed.

(2) The numbers of updates of the headers **1405, 1410, 1414** and **1416** respectively added to the first through fourth ECC blocks **1401** through **1404** are compared with one another. When the numbers of updates of the headers **1405**, **1410**, **1414** and **1416** are all of the same value, the SDL **1400** is determined to have been updated normally.

(3) Steps (1) and (2) are performed on all the SDLs in DMA2 through DMA4.

(4) Regarding the SDLs determined to have been updated normally in step (3), the numbers of updates of the SDLs included in the header are compared with one another. The SDL having the largest number of updates is determined to be the correct SDL (latest SDL).

[0034] As described above, when the size of the SDL **1400** exceeds 1ECC size, a header is provided for each 1ECC block of the SDL, so that the correct SDL can be determined even when the power of the disc drive apparatus is turned off. Thus, the reliability of user data is guaranteed with no user data being lost.

[0035] There is another conventional technology for improving the reliability of data (see, for example, Japanese Laid-Open Publication No. 8-293187).

[0036] Figure **15** shows a data structure of another conventional information recording medium **1500**.

[0037] The structure of the information recording medium **1500** is identical with the structure of the information recording medium **1200** except for the structure of an SDL **1501** and except that the size of the SDL **1501** is not limited to 1ECC size. Regarding Figure **15**, identical elements previously discussed with respect to Figure **12** bear identical reference numerals and the detailed descriptions thereof will be omitted.

[0038] The SDL **1501** includes a defect list identifier **1502** which represents that the area is the SDL **1501**, a reserved field **1503** for future expansion, first update information **1504** and second update information **1510** for determining whether defect management information is old or new, a registered defect number **1505** which represents the number of defect sectors registered in the SDL **1501**, first defect position information **1506** and second defect position information **1508** which represent the position of a defect sector, first substitute position information **1507** and second substitute position information **1509** which represent the position of a substitute sector for substituting the defect sector, and an unused field **1511** for registering defect sectors which may be detected in the future. The first update information **1504** and the second update information **1510** are, for example, numbers of times of recording. As long as the SDL **1501** is updated normally, the content of the first update information **1504** and the content of the second update information **1510** are identical to each other.

[0039] In this case, the disc drive apparatus determines the update result of the defect management areas (DMA1 through DMA4) by the following procedure.

(1) Regarding the SDL **1501**, the content of the first update information **1504** and the content of the second update information **1510** are compared with one another. When the content of the first update information **1504** and the content of the second update information **1510** are identical to each other, the SDL **1501** is determined to have been updated normally.

(2) Step (1) is performed on all the SDLs in DMA2 through DMA4.

(3) Regarding the SDLs determined to have been updated normally in step (2), the contents of the update information in the SDLs are compared with one another. The SDL having the largest amount of update information is determined to be the correct SDL (latest SDL).

[0040] As described above, as long as the first update information and the second update information added to the SDL included in one of DMA1 through DMA4 are correctly read, the determination of the correct SDL can be performed accurately, regardless of the size of the SDLs.

[0041] However, the SDL **1400** shown in Figure **14** has the following problems. A header needs to be added to all of the four ECC blocks included in the SDL **1400**. This lowers the processing efficiency of updating the SDL **1400.** In addition, a header (for example, the header **1410**) is provided between one defect entry (for example, the Mth defect entry **1409**) and another defect entry (for example, the (M+1)th defect entry **1411**). Due to this structure, the operations of, for example, searching for, adding, and deleting a defect entry are complicated.

[0042] The information recording medium **1500** shown in Figure **15** has the problem that the second up-

date information **1511** may not be correctly read.

[0043] Figure **16** shows data structures of defect lists in various states of the SDL **1501** in the information recording medium **1500** shown in Figure **15**. Part (a) shows a data structure of a pre-update defect list. Part (b) shows a data structure of a defect list which was updated normally. Part (c) shows a data structure of a defect list which was not updated normally. With reference to Figure **16**, how the SDL **1501** is updated, in the case where a sector which was previously determined as being registered as a defect area and then determined as being normal later, will be described.

[0044] The data structure of the SDL **1501** shown in part (a) of Figure **16** is the same as that shown in Figure **15.** In part (a) of Figure **16,** the content of the first update information **1504** and the second update information **1510** are both M, and the registered defect number **1505** is 2.

[0045] Part (b) of Figure **16** shows a post-update data structure of the SDL **1501** in the case where the SDL **1501** is updated normally. The content of the first update information **1504** is updated from M to M+1. The registered defect number **1505** is updated from 2 to 1. The position information of the defect sector which has been determined as being normal (second defect position information **1508**) and the position information of the substitute sector for substituting that sector (second substitute position information **1509**) are deleted. Thus, the first defect position information **1506** and the first defect position information **1507** are left. The content of the second update information **1510** is updated from M to M+1, like the first update information **1504**. The second update information **1510** is located subsequent to the first substitute position information **1507**. The unused field **1511** is increased by the size corresponding to the second defect position information **1508** and the second substitute position information **1509** which have been deleted.

[0046] Part (c) of Figure **16** shows a post-update data structure of the SDL **1501** in the case where the SDL **1501** is not updated normally. It is assumed that immediately after the registered defect number **1505** is updated, the disc drive apparatus is turned off. In this case, the first update information **1504** and the registered defect number **1505** are updated normally as in part (b) of Figure **16**. However, the second defect position information **1508**, the second substitute position information **1509**, the second update information **1510** and the unused field **1511** remain the same as those in the pre-update data structure shown in part (a) of Figure **16**.

[0047] In the case of the data structure shown in part (c) of Figure **16**, determination on the update result is performed. The disc drive apparatus uses, for example, the updated registered defect number **1505** to read the second defect position information **1508** as the second update information **1510**. The disc drive apparatus compares the content of the first update information **1504** and the content of the second defect position information **1508** read as the second update information **1510**. When the content of the first update information **1504** and the content of the second defect position information **1508** unfortunately match each other, the disc drive apparatus determines that the SDL **1501** has been updated normally even though the updating of the SDL **1501** was a failure.

[0048] In the case where the information recording medium **1500** shown in Figure **15** considers error correction of the size of 1ECC and the size of the SDL **1501** does not exceed 1ECC size, the problem described above with reference to part (c) of Figure **16** does not occur. However, when the size of the SDL **1501** exceeds 1ECC size, the above-described problem occurs.

SUMMARY OF THE INVENTION

[0049] According to one aspect of the invention, an information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated.

[0050] In one embodiment of the invention, the defect list includes at least two blocks, and the defect list is recorded in units of one block.

[0051] According to another aspect of the invention, a recording apparatus for recording information on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor

includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated. The recording apparatus includes a recording section for recording the information on the information recording medium, a storage section for storing the information to be recorded on the information recording medium, and a latest defect list, and a control section for controlling execution of defect management processing which is performed using the recording section and the storage section. The latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$. The latest header includes first latest update times information and a latest defect entry number P. The latest anchor includes second update times information having a content identical to that of the first update times information. The defect management processing includes the steps of (a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case, (b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P'; (c) incrementing, by one, each of the first latest update times information and the second latest update times information, and (d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

[0052] In one embodiment of the invention, the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries , and the updated latest header.

[0053] In one embodiment of the invention, the step (b) includes the step of, when it is determined in the step (a) that another defect area exists in the data area, adding another defect entry to the latest defect list.

[0054] In one embodiment of the invention, the step (b) includes the step of, when it is determined in the step (a) that a normal defect area exists among the N number of defect areas, deleting a defect entry including position information on a position of the normal defect area from the P number of latest defect entries.

[0055] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The control section controls execution of the step (d) for the another defect management area.

[0056] According to still another aspect of the invention, a recording method for recording information on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated. The recording is performed using a latest defect list. The latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$. The latest header includes the first update times information and a latest defect entry number P. The latest anchor includes second update times information having a content identical to that of the first update times information. The recording method includes the steps of (a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case, (b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P'; (c) incrementing, by one, each of the first latest update times information and the second latest update times information, and (d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

[0057] In one embodiment of the invention, the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries , and the updated latest header.

[0058] In one embodiment of the invention, the step (b) includes the step of, when it is determined in the step (a) that another defect area exists in the data area, adding another defect entry to the latest defect list.

[0059] In one embodiment of the invention, the step

(b) includes the step of, when it is determined in the step (a) that a normal defect area exists among the N number of defect areas, deleting a defect entry including position information on a position of the normal defect area from the P number of latest defect entries.

[0060] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The control section controls execution of the step (d) for the another defect management area.

[0061] According to still another aspect of the invention, a reproduction apparatus for reproducing information recorded on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor. The header located at a fixed position in the defect list, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated. The reproduction apparatus includes a reproduction section for reproducing the information recorded on the information recording medium, a storage section for storing the reproduced information, and a control section for controlling execution of defect management processing which is performed using the reproduction section and the storage section, the control section having an inherent defect list identifier for identifying the defect list and an inherent anchor identifier for identifying the anchor of the defect list. The defect management processing includes the steps of (a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of the inherent defect list identifier matches a content of the reproduced defect list identifier, (b) calculating a position of the anchor in the defect list using the reproduced defect entry number when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier, (c) reproducing the anchor identifier and the second update times information based on the calculated position of the anchor, and determining whether or not a content of the inherent anchor identifier matches a content of the reproduced anchor identifier, (d) determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (c) that the content of the inherent anchor identifier matches the content of the reproduced anchor identifier, and (e) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (d) that the content of the first update times information matches the content of the second update times information.

[0062] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The control section controls execution of the defect management processing for the another defect management area. The step (e) includes the steps of (e_1) performing the steps (a) through (d) for the another defect management area, and (e_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

[0063] According to still another aspect of the invention, a reproduction method for reproducing information recorded on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor. The header located at a fixed position in the defect list, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated. The reproduction method includes the steps of (a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of an inherent defect list identifier for identifying the defect list matches a content of the reproduced defect list identifier, (b) calculating a position of the anchor in the defect list using the reproduced defect entry number when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier, (c) reproducing the anchor identifier and the second update times information based on the calculated position of the anchor, and determining whether or not a content of an inherent anchor identifier for identi-

fying the anchor of the defect list matches a content of the reproduced anchor identifier, (d) determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (c) that the content of the inherent anchor identifier matches the content of the reproduced anchor identifier, and (e) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (d) that the content of the first update times information matches the content of the second update times information.

[0064] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The step (e) includes the steps of (e_1) performing the steps (a) through (d) for the another defect management area, and (e_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

[0065] According to still another aspect of the invention, an information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes second update times information representing the number of times which the defect list has been updated.

[0066] In one embodiment of the invention, the defect list includes at least two blocks, and the defect list is recorded in units of one block.

[0067] According to still another aspect of the invention, a recording apparatus for recording information on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes second update times information representing the number of times which the defect list has been updated. The recording apparatus includes a recording section for recording the information on the information recording medium, a storage section for storing the information to be recorded on the information recording medium, and a latest defect list, and a control section for controlling execution of defect management processing which is performed using the recording section and the storage section. The latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$. The latest header includes first latest update times information and a latest defect entry number P. The latest anchor includes second update times information having a content identical to that of the first update times information. The defect management processing includes the steps of (a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case, (b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P' ; (c) incrementing, by one, each of the first latest update times information and the second latest update times information, and (d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

[0068] In one embodiment of the invention, the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

[0069] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The control section controls execution of the step (d) for the another defect management area.

[0070] According to still another aspect of the invention, a recording method for recording information on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect

areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes second update times information representing the number of times which the defect list has been updated. The recording is performed using a latest defect list. The latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$. The latest header includes the first update times information and a latest defect entry number P. The latest anchor includes second update times information having a content identical to that of the first update times information. The recording method includes the steps of (a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case, (b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P'; (c) incrementing, by one, each of the first latest update times information and the second latest update times information, and (d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

[0071] In one embodiment of the invention, the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

[0072] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The method further comprises the step of executing the step (d) for the another defect management area.

[0073] According to still another aspect of the invention, a reproduction apparatus for reproducing information recorded on an information recording medium is provided. The information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes second update times information representing the number of times which the defect list has been updated. The reproduction apparatus includes a reproduction section for reproducing the information recorded on the information recording medium, a storage section for storing the reproduced information, and a control section for controlling execution of defect management processing which is performed using the reproduction section and the storage section, the control section having an inherent defect list identifier for identifying the defect list. The defect management processing includes the steps of (a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of the inherent defect list identifier matches a content of the reproduced defect list identifier, (b) reproducing the second update times information included in the anchor and determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier, and (c) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (b) that the content of the first update times information matches the content of the second update times information.

[0074] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The control section controls execution of the defect management processing for the another defect management area. The step (c) includes the steps of (c_1) performing the steps (a) and (b) for the another defect management area, and (c_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

[0075] According to still another aspect of the invention, a reproduction method for reproducing information recorded on an information recording medium is provided. The information recording medium includes a data

area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$. The defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list. The header, the N number of defect entries, and the anchor are located in this order in the defect list. The header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries. The anchor includes second update times information representing the number of times which the defect list has been updated. The reproduction method includes the steps of (a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of an inherent defect list identifier for identifying the defect list matches a content of the reproduced defect list identifier, (b) reproducing the second update times information included in the anchor and determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier, and (c) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (b) that the content of the first update times information matches the content of the second update times information.

[0076] In one embodiment of the invention, the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area. The step (c) includes the steps of (c_1) performing the steps (a) and (b) for the another defect management area, and (c_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

[0077] Thus, the invention described herein makes possible the advantages of providing an information recording medium, a recording apparatus, a reproduction apparatus, a recording method, and a reproduction method, allowing for updating of an SDL (defect list) having a size of 2ECC or larger and deletion of a defect entry.

[0078] These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0079]

Figure **1** shows a data structure of an information recording medium **100** according to a first example of the present invention;

Figures **2A** through **2D** show detailed data structures of a header **121**, a first defect entry **122**, an anchor **126**, and an unused area **113**;

Figure **3** is a block diagram of a recording and reproduction apparatus **300** according to a first example of the present invention;

Figure **4** is a flowchart illustrating a procedure of defect management processing for specifying the latest defect list in the first example;

Figure **5** is flowchart illustrating a procedure of defect management processing for updating the latest defect list in the first example;

Figure **6** shows a data structure of a defect list, during the processing for adding a defect entry in the first example, in various states of (a) before update, (b) when the defect list has been updated normally and (c) when the defect list has not been updated normally;

Figure **7** shows a data structure of a defect list, during the processing for deleting a defect entry in the first example, in various states of (a) before update, (b) when the defect list has been updated normally and (c) when the defect list has not been updated normally;

Figure **8** shows a data structure of a defect list, during the processing for changing a defect entry in the first example, in various states of (a) before update, (b) when the defect list has been updated normally and (c) when the defect list has not been updated normally;

Figure **9** shows a data structure of an information recording medium **900** according to a second example of the present invention;

Figure **10** is a flowchart illustrating a procedure of defect management processing for specifying the latest defect list in the second example;

Figure **11** shows a data structure of a defect list, during the processing for adding a defect entry in the second example, in various states of (a) before update, (b) when the defect list has been updated normally and (c) when the defect list has not been

updated normally;

Figure **12** shows a data structure of an information recording medium **1200** according to the DVD-RAM Standards;

Figure **13** shows a detailed data structure of an SDL **1212**;

Figure **14** shows a data structure of an SDL **1400** having 4ECC size;

Figure **15** is a data structure of another conventional information recording medium **1500;** and

Figure **16** shows a data structure of an SDL **1501** of the information recording medium **1500** shown in Figure **15** in various states of (a) before update, (b) when the defect list has been updated normally and (c) when the defect list has not been updated normally.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0080] Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

(Example 1)

(1) Information recording medium

[0081] Figure **1** shows a data structure of an information recording medium **100** according to a first example of the present invention.

[0082] The information recording medium (optical disc) **100** may be, for example, a rewritable optical disc. The optical disc **100** is assumed to be subjected to error correction in units of 1 ECC block. An ECC block is a unit of error correction in the field of optical discs. An ECC block has, for example, a size of 32 kbytes in 16 sectors (each sector has a size of 2 kbytes). This size of one ECC block will be referred to as "1ECC size", hereinafter. It is assumed that the recording of information on the optical disc **100** and updating of the information on the optical disc **100** are performed in units of 1ECC.

[0083] The data structure shown in Figure **1** is the structure of the optical disc **100** after position information on N number of defect areas in a defect management area is normally recorded (N is an integer satisfying $N \geq 0$). A defect area is, for example, a defect sector.

[0084] The optical disc **100** includes a data area **102** for recording user data, and a lead-in area **101** and a lead-out area **103** acting as a buffer area when a recording and reproduction apparatus (not shown) overruns by the movement of an optical head (not shown).

[0085] The data area **102** includes a user area **106** for recording user data and a spare area **107**. When there is a defect area (for example, a defect sector) in the user area **106**, the user data which is to be recorded in the defect area is recorded in the spare area **107** instead of a portion of the user area **106** corresponding to the defect area.

[0086] The lead-in area **101** includes a first defect management area **104** and a second defect management area **105** for recording defect management information used for managing a defect area existing in the data area **102**.

[0087] The lead-out area **103** includes a third defect management area **108** and a fourth defect management area **109** for recording defect management information used for managing a defect area existing in the data area **102**, like the lead-in area **101**.

[0088] The first defect management area **104**, the second defect management area **105**, the third defect management area **108**, and the fourth defect management area **109** are respectively located at physically specific positions on the optical disc **100**.

[0089] In the first defect management area **104**, the second defect management area **105**, the third defect management area **108** and the fourth defect management area **109**, the same information for defect management is recorded in multiplex. The reason for this is, as described above, that the information recorded in the first, second, third and fourth defect management areas **104, 105, 108,** and **109** cannot be a target of defect management. Even if some of the first, second, third and fourth defect management areas **104, 105, 108,** and **109** have a defect area and the information recorded in the defect area cannot be reproduced, as long as at least one of the four defect management areas is defect-free, the defect management information recorded in that area can be normally reproduced. Accordingly, loss of the user data is prevented, which improves reliability. In the first example, the optical disc **100** includes the four defect management areas **104, 105, 108,** and **109**, but the number of defect management areas may be any number of one or more.

[0090] In the first defect management area **104**, a disc definition structure **111** and a defect list **112** for managing N number of defect areas existing in the data area **102** (N is an integer satisfying $N \geq 0$) are recorded. The first defect management area **104** includes an unused area **113.**

[0091] The disc definition structure **111** is information representing the disc structure, for example, whether or not the disc **100** has been subjected to defect management. This information also includes information regarding the spare area **107.** The disc definition structure **111** is located at a physically specific position in the first defect management area **104**. The disc definition structure **111** has a prescribed size.

[0092] In the unused area **113**, currently meaningless information is recorded. Generally, padding data **127** (for example, 0) is recorded in the unused area **113.**

When a new defect area is detected in the user area **106**, a defect entry for managing the new defect area is added to the defect list **112.** As a result, the size of the unused area **113** is decreased by the size of the added defect entry.

[0093] The defect list **112** includes a header **121**, a first defect entry **122,** a second defect entry **123,** ..., an (N-1)th defect entry **124**, an Nth entry **125**, and an anchor **126**. The header **121**, the first through Nth entries **122** through **125**, and the anchor **126** are located in this order in the defect list **112**.

[0094] In the first example, it is assumed that the total of the size of the defect list **112** and the size of the unused area **113** is 4ECC. The total size is not limited to 4ECC and is arbitrary.

[0095] The header **121** includes a defect list identifier **131** which represents that the area is the defect list **112**, a defect entry number **132** which represents the number of entries included in the defect list **112**, and first update times information **133** which represents the number of times which an updated defect list has been recorded in the first defect management area **104.** In Figure **1,** the defect entry number **132** is N (N is an integer satisfying $N \geq 0$), and the content of the first update times information **133** is M (M is an integer satisfying $M \geq 0$). The defect list identifier **131** may be located, for example, at the start of the header **121** as shown in Figure **1**.

[0096] The header **121** is located at a physically specified position. In the first example, the header **121** is located at the start of the defect list **112**. The position of the header **121** in the defect list **112** is arbitrary as long as the header **121**, the first through Nth defect entries **122** through **125**, and the anchor **126** are located in this order in the defect list **112.**

[0097] In the case of the optical disc **100** shown in Figure **1,** the defect entry number **132** is N. Thus, the defect list **112** includes the first defect entry **122,** ..., and the Nth defect entry **125**. The first defect entry **122** includes first defect position information **141** which is position information showing the position of a defect area, and first substitute position information **142** which is position information showing the position of a part of the spare area **107** which is usable instead of the defect area. Likewise, the second defect entry **123** includes second defect position information and second substitute position information. The (N-1)th defect entry **124** and the Nth defect entry **125** also have substantially the same structure. Here, each of the first defect position information **141** and the first substitute position information **142** is generally a sector number.

[0098] The defect entries are generally located such that the defect position information included therein is in an ascending order. More specifically, when, for example, the defect position information is a sector number, defect position information having the smaller sector number is located in the first defect entry **122** as the first defect position information **141**. After this, the defect entries are located in the order of the sector numbers. Defect position information having the larger sector number is located in the Nth defect entry **125** as Nth defect position information.

[0099] The defect entries in the defect list **112** do not need to be located in an ascending order. For example, the defect entries may be located such that the sector numbers are in a descending order. Alternatively, the defect entries may be located randomly.

[0100] The anchor **126** includes an anchor identifier **151** for identifying that the area is an anchor of the defect list **112,** second update times information **152** which represents the number of times which the updated defect list has been recorded in the first defect management area **104**, and reserve information **153** for future expansion. In Figure **1**, the content of the second update times information **152** is M (M is an integer satisfying $M \geq 0$), and is the same as that of the first update times information **133.** As long as the first defect management area **104** is updated normally, the content of the first update times information **133** and the content of the second update times information **152** are identical to each other. The anchor identifier **151** may be located, for example, at the start of the anchor **126** as shown in Figure **1**.

[0101] In this specification, the first and second update times information **133** and **152** represent the number of times which the updated defect list has been recorded in the first defect management area **104** (i.e., the number of times which the defect list **112** has been updated and recorded on the optical disc **100**). The first and second update times information **133** and **152** may represent the number of times which the defect list has been updated (i.e., the number of times which the defect list has been updated in the storage section described below). In the following description, the first and second update times information **133** and **152** represent the number of times which the updated defect list has been recorded in the first defect management area **104**.

[0102] The anchor **126** is located subsequently to the Nth defect entry **125**. It should be noted that since the size of the defect list **112** is variable, the position at which the anchor **126** is located is also variable.

[0103] Next, the header **121**, the first defect entry **122**, the anchor **126** and the unused area **113** will be described in detail.

[0104] Figures **2A** through **2D** respectively show detailed data structures of the header **121**, the first defect entry **122**, the anchor **126** and the unused area **113**.

[0105] In Figures **2A** through **2D**, "BP" represents the bit position, and "Val" represents the binary value corresponding to each BP. In the example shown in Figures **2A** through **2D**, the size of each of the header **121**, the first defect entry **122**, the anchor **126** and the unused area **113** is 8 bytes (bit position 0 through bit position 63).

[0106] Figure **2A** shows an exemplary detailed structure of the header **121**. In this example, Val for only the bit position 62 of the defect list identifier **131** is 1 (Val=1); i.e., 0×4000 in hexadecimal representation.

[0107] Figure **2B** shows an exemplary detailed structure of the first defect entry **122**. It is assumed that the maximum number of the sector among the sectors usable in the data area **102** is 0 × 07FFFFFF in hexadecimal representation. The maximum value which has a possibility of being registered as the first defect position information **141** in the first defect entry **122** is 0 × 07FFFFFF in hexadecimal representation as shown in Figure **2B**.

[0108] Figure **2C** shows an exemplary detailed structure of the anchor **126.** In this example, Val for all the bit positions 59 through 63 in the anchor identifier **151** is 1 (Val = 1); i.e., 0 × FFFF in hexadecimal representation.

[0109] Figure **2D** shows an exemplary detailed structure of the unused area **113.** In the unused area **113,** the padding data **127** is generally recorded. In the unused area **113,** Val = 0. In Figure **2D,** 0 is recorded as the padding data, but the padding data is not limited to 0.

[0110] For the defect list identifier **131** and the anchor identifier **151**, a value which is distinguishable from any other defect entry and that of the unused area **113** is adopted. As shown in Figure **2C,** Val = 1 is set for at least one of the bit positions 59 through 63 which are never 1 in any defect entry or the unused area **113**.

[0111] Similarly, as shown in Figure **2A,** Val = 1 is set for at least one of the bit positions 59 through 63 which are never 1 in any defect entry or the unused area **113**, such that the value sequence of the bit positions 59 through 63 in the defect list identifier **131** is different from that of the bit positions 59 through 63 in the anchor identifier **151**.

[0112] Owing to such settings, the anchor identifier **151** is distinguishable from the defect list identifier **131**, any defect entry, and the unused area **113**. The defect list identifier **131** is also distinguishable from the anchor identifier **151**, any defect entry, and the unused area **113**.

[0113] The values for the defect list identifier **131** and the anchor identifier **151** in Figures **2A** and **2C** are mere examples, and the values are not limited to these.

[0114] In the first example, the defect list identifier **131** and the anchor identifier **151** are distinguished from any defect entry and the unused area **113** and further the defect list identifier **131** and the anchor identifier **151** are distinguishable from each other as described above. Therefore, even when any defect entry is read as the anchor identifier **151** in the anchor **126**, that defect entry is never erroneously determined as the anchor identifier **151**. Accordingly, it can be easily determined whether or not the defect list **112** has been updated normally.

[0115] Since it is not necessary to provide a header for each 1ECC size, the processing efficiency of updating the defect list is improved. Since the header is not interposed between two defect entries, defect entries can be easily searched for, added, and deleted.

[0116] The following description will be made with the premise that the optical disc **100** has the data structure shown in Figure **1**.

(2) Reproduction/recording (update)

[0117] Figure **3** is a block diagram of a recording and reproduction apparatus **300** according to the first example. The recording and reproduction apparatus **300** records information on the optical disc **100** and/or reproduces information recorded on the optical disc **100**.

[0118] The recording and reproduction apparatus **300** includes a control section **301**, a recording and reproduction section **302**, and a storage section **303**.

[0119] The control section **301** controls the operation of the recording and reproduction section **302**. The control section **301** may be, for example, a CPU. The control section **301** has an inherent defect list identifier for identifying the defect list **112** of the optical disc **100** and an inherent anchor identifier for identifying the anchor **126** of the defect list **112** of the optical disc **100**, which are stored initially. The contents (values) of the inherent defect list identifier and the inherent anchor identifier are correct and are not rewritable. The control section **301** uses the recording and reproduction section **302** and the storage section **303** to control the execution of the following processing: (a) defect management processing for specifying the latest defect list among the defect lists which are recorded in the first through fourth defect management areas **104, 105, 108** and **109**; and (b) defect management processing for updating the defect lists which are recorded in the first through fourth defect management areas **104, 105, 108** and **109** into the latest defect list.

[0120] The recording and reproduction section **302** records information on the optical disc **100** and/or reproduces the information recorded on the optical disc **100**. Such recording/reproduction is performed by, for example, emitting laser so as to write the information on the optical disc **100** as a signal and/or so as to read the information written as a signal on the optical disc **100.**

[0121] The storage section **303** stores information to be recorded on the optical disc **100** and/or stores information which has been reproduced from the optical disc **100.** The storage section **303** may be, for example, a random access memory (RAM). Owing to the operation of the control section **301**, the storage section **303** includes a defect list area saved for storing the defect list **112** reproduced from a defect management area (for example, the first defect management area **104**) of the optical disc **100** or a latest defect list to be recorded in the defect management area.

(2-1) Defect management processing for specifying the latest defect list

[0122] Next, the operation of defect management processing for specifying the latest defect list performed by the recording and reproduction apparatus **300** will be described.

[0123] The control section **301** executes the defect management processing. The control section **301** fol-

lows the procedure of the defect management processing to request the recording and reproduction section **302** to reproduce the information of the disc definition structure **111** located at the start of the first defect management area **104** and store the reproduced information from the disc definition structure **111** in the storage section **303.**

[0124] Upon the request from the control section **301,** the recording and reproduction section **302** reproduces the information of the disc definition structure **111** from the optical disc **100** and stores the information in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the information of the disc definition structure **111** has been completed.

[0125] Upon receiving the report from the recording and reproduction section **302**, the control section **301** checks whether or not the optical disc **100** has been subjected to defect management, based on the information of the disc definition structure **111** stored in the storage section **303.**

[0126] When confirming that the optical disc **100** has been subjected to defect management, the control section **301** requests the recording and reproduction section **302** to reproduce the header **121** located at a fixed position of the defect list **112** (in the example of Figure **1,** at the start of the defect list **112**) recorded in the first defect management area **104** and to store the reproduced header **121** in the storage section **303**.

[0127] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the header **121** located at the start of the defect list **112** recorded in the first defect management area **104** and store the reproduced header **121** in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the header **121** has been completed.

[0128] Upon receiving the report from the recording and reproduction section **302**, the control section **301** compares the content of the inherent defect list identifier initially stored in the control section **301** with the content of the defect list identifier **131** included in the header **121** stored in the storage section **303** to check whether or not the stored information is the header **121** in the defect list **112**.

[0129] When the two contents compared match each other, the control section **301** determines that the stored information is the header **121** in the defect list **112** and proceeds with the defect management processing. When the two contents compared do not match each other, the control section **301** determines that updating of the first defect management area **104** failed (abnormal defect management area) and terminates the defect management processing. The two contents compared do not match each other when, for example, there is a defect area in the first defect management area **104** and thus information cannot be read therefrom.

[0130] In order to identify the anchor **126** in the defect list **112** recorded in the first defect management area **104**, the control section **301** uses the defect entry number **132** included in the header **121** stored in the storage section **303** to calculate the position of the start of the anchor **126** in the defect list **112**. The position of the start of the anchor **126** can be obtained by multiplying the defect entry number **132** by the size of one defect entry which is a fixed value.

[0131] The control section **301** requests the recording and reproduction section **302** to reproduce the anchor **126** in the defect list **112** based on the calculated position, and store the reproduced information in the storage section **303**.

[0132] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the information present at the designated position in the defect list **112** and stores the reproduced information in the storage section **303.** The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the information present at the designated position has been completed.

[0133] Upon receipt of the report from the recording and reproduction section **302**, the control section **301** compares the content of the inherent anchor identifier initially stored in the control section **301** with the content of the information located at the start of the entire information stored in the storage section **303** to check whether or not the stored information is the anchor **126** in the defect list **112**. The "information located at the start of the entire information stored in the storage section **303**" is the information expected to be the anchor identifier **151** included in the anchor **126**.

[0134] When the two contents compared match each other, the control section **301** determines that the stored information is the anchor **126** in the defect list **112** and proceeds with the defect management processing. When the two contents compared do not match each other, the control section **301** determines that updating of the first defect management area **104** failed (abnormal defect management area) and terminates the defect management processing. The two contents compared do not match each other when, for example, the information present at the position calculated using the defect entry number **132** is not the anchor **126**. More specifically, the two contents compared do not match each other when, for example, the recording and reproduction apparatus **300** is turned off while the first through Nth defect entries **122** through **125** in the defect list **112** are being updated. In this case, the defect entry number **132** included in the header **121** does not match the total number of the first through Nth defect entries **122** through **125.**

[0135] The control section **301** compares the content of the first update times information **133** included in the header **121** with the second update times information **152** included in the anchor **126** stored in the storage section **303**.

[0136] When the two contents compared match each

other, the control section **301** determines that the first defect management area **104** has been updated normally, and proceeds with the defect management processing.

[0137] When the two contents compared do not match each other, the control section **301** determines that updating of the first defect management area **104** failed (abnormal defect management area) and terminates the defect management processing. The two contents compared do not match each other when, for example, the recording and reproduction apparatus **300** is turned off while the first through Nth defect entries **122** through **125** in the defect list **112** are being updated and therefore updating of the defect entries **122** through **125** is not completed. In this case, the content of the first update times information **133** included in the header **121** does not match the content of the second update times information **152** included in the anchor **126**.

[0138] The control section **301** performs substantially the same processing for each of the second defect management area **105**, the third defect management area **108** and the fourth defect management area **109**.

[0139] After checking whether or not each of the first through fourth defect management areas **104, 105, 108** and **109** is a normal defect management area, the control section **301** specifies the latest defect management area among the defect management areas which have been determined to be normal, as follows. The control section **301** makes a comparison of the first update times information **133** recorded in the defect management areas which have been determined to be normal, and specifies the defect management area having the largest number of updates as the latest defect management area. The defect list recorded in the specified latest defect management area is specified as the latest defect list.

[0140] For specifying the latest defect management area, the second update times information **152** included in the anchor **126** may be used instead of the first update times information **133.**

[0141] The control section **301** requests the recording and reproduction section **302** to reproduce the defect list recorded in the specified latest defect management area and store the reproduced defect list in the defect list area saved in the storage section **303**.

[0142] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the defect list recorded in the specified latest defect management area and stores the reproduced defect list in the defect list area in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the defect list has been completed.

[0143] Thus, the operation of defect management processing for specifying the latest defect list performed by the recording and reproduction apparatus **300** is completed.

[0144] Using the specified latest defect list, the user data recorded in the data area **102**, for example, can be reproduced. In this case, the control section **301** requests the recording and reproduction section **302** to reproduce the user data based on the latest defect list and store the reproduced user data in the storage section **303**.

[0145] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the user data from the data area **102** and stores the reproduced user data in the storage section **303**.

[0146] Information recording may be performed using the specified latest defect list.

[0147] Figure **4** shows a procedure of defect management processing for specifying the latest defect list in the first example. The defect management processing is executed by the control section **301**. Hereinafter, each step of the procedure of defect management processing will be described. The procedure of defect management processing is started after it is confirmed that the optical disc **100** has been subjected to defect management. Whether or not the optical disc **100** has been subjected to defect management is determined based on the disc definition structure **111** in the optical disc **100**.

[0148] Step S401: The defect list identifier **131,** the defect entry number **132** and the first update times information **133** included in the header **121** are reproduced. The content of the reproduced defect list identifier **131** is compared with the content of the inherent defect list identifier. The inherent defect list identifier identifies the defect list **112** in the optical disc **100**. The inherent defect list identifier has a correct value which is not rewritable. The inherent defect list identifier may be initially stored in the control section **301**. When the two contents compared match each other, the defect management processing advances to step S402. When the two contents compared do not match each other, the defect management processing advances to step S406.

[0149] Step S402: When the content of the defect list identifier **131** and the content of the inherent defect list identifier are determined to match each other in step S401, the reproduced information is determined to be the header **121** in the defect list **112**. Using the defect entry number **132** included in the header **121**, the position of the start of the anchor **126** in the defect list **112** is calculated. The position of the start of the anchor **126** is obtained by multiplying the defect entry number **132** by the size of one defect entry which is a fixed value. The defect management processing advances to step S403.

[0150] Step S403: Based on the position obtained in step S402, information expected to be the anchor identifier **151** and the second update times information **152** included in the anchor **126** are reproduced. The content of the information expected to be the anchor identifier **151** is compared with the content of the inherent anchor identifier. The inherent anchor identifier identifies the anchor of the defect list **112.** The inherent anchor identifier has a correct value which is not rewritable. The in-

herent anchor identifier is initially stored in the control section **301**. When the two contents compared are determined to match each other, the defect management processing advances to step S404. When the two contents compared are determined not to match each other, the defect management processing advances to step S406.

[0151] Step S404: When the content of the information expected to be the anchor identifier **151** and the content of the inherent anchor identifier are determined to match each other in step S403, the stored information is determined to be the anchor **126** in the defect list **112**. The content of the first update times information **133** included in the header **121** is compared with the content of the second update times information **152** included in the anchor **126**. When the two contents compared are determined to match each other, the defect management processing advances to step S405. When the two contents compared are determined not to match each other, the defect management processing advances to step S406.

[0152] Step S405: When the content of the first update times information **133** and the content of the second update times information **152** are determined to match each other in step S404, the first defect management area **104** is determined to have been updated normally. Then, the defect management processing advances to step S407.

[0153] Step S406: When the contents compared are determined not to match each other in steps S401, S403 or S404, updating of the first defect management area **104** is determined to have failed (abnormal defect management area), and the defect management processing for the first defect management area **104** is terminated. The defect management processing advances to step S407.

[0154] Step S407: It is determined whether or not the operations in steps S401 through S406 have been performed for all the defect management areas in the optical disc **100**. When the operations in steps S401 through S406 have not been performed for all the defect management areas, the defect management processing returns to step S401. When the operations in steps S401 through S406 have been performed for all the defect management areas, the defect management processing advances to step S408.

[0155] Step S408: The latest defect list is specified. More specifically, the latest defect management area among the defect management areas determined to be normal is specified, as follows. A comparison is made of the first update times information (or the second update times information) recorded in the defect management areas determined to be normal, and the defect management area having the largest number of updates is specified as the latest defect management area. The defect list recorded in the specified latest defect management area is specified as the latest defect list.

[0156] When the latest defect list of the optical disc **100** is specified by steps S401 through S408, the defect management processing is completed. Using the latest defect list obtained in step S408, the user data recorded in the data area **102**, for example, can be reproduced.

(2-2) Defect management processing for updating the latest defect list

[0157] Returning to Figure **3**, the operation of defect management processing for updating the latest defect list performed by the recording and reproduction apparatus **300** will be described. In the following example, the defect list is updated when another defect area is detected while the user data is being recorded in the data area **102** of the optical disc **100**, or when a portion of the user area **106** which was previously determined to be a defect area is determined to be a normal defect area while the user data recorded in the data area **102** is being reproduced. Throughout this specification, a "normal defect area" is defined to mean an area which was previously determined to be a defect area but currently has no defect and allows information to be recorded therein and/or allows information therein to be reproduced. An area which was previously determined to be a defect area is currently determined to be a normal defect area when, for example, the defect is caused by dust or stain such as a fingerprint on the surface of the optical disc. In this case, when the user cleans the surface of the optical disc to remove the dust or stain, the area in which the dust or stain existed (i.e., the area which was previously determined to be a defect area) is currently determined to be a normal area usable for recording/reproduction.

[0158] The storage section **303** stores the latest defect list. The latest defect list may be located in the defect list area in the storage section **303**. The latest defect list includes the latest header, P number of latest defect entries (P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$), and the latest anchor. In the first example, the latest header, the P number of latest defect entries, and the latest anchor are located in the latest defect list in this order. The latest header is located at a fixed position in the latest defect list. The latest anchor is located subsequently to the Pth latest defect entry among the P number of latest defect entries. The latest header includes the latest defect list identifier, the first latest update times information and the latest defect entry number P. The content of the latest defect list identifier is always the same as that of the inherent defect list identifier stored in the control section **301**. The latest anchor includes the latest anchor identifier and the second latest update times information which has the same content as that of the first latest update times information. The content of the latest anchor identifier is always the same as that of the inherent anchor list identifier stored in the control section **301**. It is assumed that the P number of latest defect entries are arranged in an ascending order of the defect position information (defect

sector numbers). The latest defect list may include an unused area. It is not always necessary that the latest header includes the latest defect list identifier. Similarly, it is not always necessary that the latest anchor includes the latest anchor identifier.

[0159] The above-described arrangement of the latest header and the P number of latest defect entries and the latest anchor is merely an example. The arrangement of the latest header and the P number of latest defect entries and the latest anchor in the latest defect list is arbitrary.

[0160] The control section **301** executes the defect management processing. The control section **301** requests the recording and reproduction section **302** to determine whether (a) another defect area exists in the data area **102**, (b) a defect area which was previously determined to be a defect area is currently a normal defect area, or (c) neither (a) nor (b) is the case. Whether or not another defect area exists in the data area **102** is determined by, for example, comparing a signal obtained by reproducing data immediately after user data is recorded with a signal representing user data to be recorded. When these signals match each other, the user data is determined to have been normally recorded in the data area **102**. When these signals do not match each other, it is determined that the user data has not been normally recorded in the data area **102** and another defect area exists in the data area **102**.

[0161] When determining that another defect area exists in the data area **102** or that the area which was previously determined to be a defect area is currently a normal defect area, the control section **301** updates the latest defect list stored in the storage section **303**.

[0162] Specific procedures of updating the latest defect list will be described. There are three cases of updating the latest defect list, namely, (i) addition of a defect entry, (ii) deletion of a defect entry; and (iii) change of a defect entry. Each of these cases will be described one by one.

(i) Addition of a defect entry

[0163] When it is determined that another defect area exists in the user area **106**, a defect entry including the position information on the position of the another defect area is added to the latest defect list. Based on the defect position information on the detected defect area, the control section **301** determines the position of the defect entry to be added. The control section **301** shifts the other defect entries and the latest anchor existing subsequent to the determined position toward the unused area, and adds the defect entry including the position information on the another defect area at the determined position. As a result, the P number of latest defect entries are updated to P' number of latest defect entries ($P \neq P'$, $P < P'$).

[0164] Following the addition of the defect entry, the control section **301** updates the latest defect entry number from P into P'. In this case, the latest defect entry number is increased by the number of the added defect entries (i.e., by the number of the detected defect sectors).

[0165] After the P number of latest defect entries and the latest defect entry number P are updated, the control section **301** increments, by one, the content of the first latest update times information included in the latest header and the content of the second latest update times information included in the latest anchor.

(ii) Deletion of a defect entry

[0166] When an area which was previously determined to be a defect area is currently determined to be a normal defect area, the control section **301** deletes the defect entry including the position information on the area determined to be the normal defect area. The control section **301** then shifts the defect entries located subsequent to the deleted defect entry and the latest anchor toward the latest header by the size of the deleted defect entry. The unused area is expanded by the size of the deleted defect entry, and the control section **301** records padding data (for example, 0) in the expanded portion of the unused area. As a result, the P number of latest defect entries are updated to P' number of latest defect entries ($P \neq P'$, $P > P'$).

[0167] Following the deletion of the defect entry, the control section **301** updates the latest defect entry number from P into P'. In this case, the latest defect entry number is decreased by the number of the deleted defect entries (i.e., by the number of the defect sectors determined to be normal).

[0168] After the P number of latest defect entries and the latest defect entry number P are updated, the control section **301** increments, by one, the content of the first latest update times information included in the latest header and the content of the second latest update times information included in the latest anchor.

(iii) Change of a defect entry

[0169] When another defect area is determined to exist in the spare area **107**, the control section **301** rewrites the substitute position information corresponding to the another defect area in the latest defect list. The substitute position information corresponding to the another defect area is rewritten into substitute position information representing a portion other than the another defect area in the spare area **107**.

[0170] The control section **301** changes the latest defect entry number from P to P' ($P = P'$ since no defect entry is added to or deleted from the latest defect list). Although the number of the latest defect entries remains the same, the substitute position information included is different. Throughout this specification, "updating of a defect list" encompasses the case of not changing the number of defect entries included in the defect list in ad-

dition to the case of changing the number of defect entries included in the defect list.

[0171] After the P number of latest defect entries and the latest defect entry number P are updated, the control section 301 increments, by one, the content of the first latest update times information included in the latest header and the content of the second latest update times information included in the latest anchor.

[0172] The operations (i) through (iii) are performed by the control section **301** for the latest defect list stored in the storage section **303**. In the case where the first and second update times information **133** and **152** represent the number of times which the updated latest defect list has been recorded in the first defect management area **104**, the first and second latest update times information may each be incremented by one only once before the updated latest defect list is recorded in the first defect management area **104**. By contrast, in the case where the first and second update times information **133** and **152** represent the number of times which the latest defect list has been updated in the storage section **303**, the first and second latest update times information may be incremented by one each time the latest defect entries and the latest defect entry number are updated.

[0173] The control section **301** requests the recording and reproduction section **302** to record the latest defect list updated in the storage section **303** in the first defect management area **104** of the optical disc **100**. For example, the control section **301** requests the recording and reproduction section **302** to record the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor in the first defect management area **104** in this order.

[0174] Upon the request from the control section **301**, the recording and reproduction section **302** records the updated latest defect list in the first defect management area **104**. The updated defect list replacing the defect list **112** is recorded in the first defect management area **104** in the order of the latest header replacing the header **121**, the latest defect entries replacing the first through Nth defect entries **122** through **125**, and the latest anchor replacing the anchor **126**. The recording and reproduction section **302** reports to the control section **301** that the recording of the updated latest defect list in the first defect management area **104** has been completed.

[0175] The control section **301** requests the recording and reproduction section **302** to record the latest defect list updated in the storage section **303** in each of the second through fourth defect management areas **105, 108** and **109**. More specifically, again, the control section **301** requests the recording and reproduction section **302** to record the updated latest header, the updated latest defect entries, and the updated latest anchor in this order in the second through fourth defect management areas **105, 108** and **109**.

[0176] Upon the request from the control section **301**, the recording and reproduction section **302** records the updated latest defect list in each of the second through fourth defect management areas **105, 108** and **109**.

[0177] Thus, the operation of defect management processing for updating the latest defect list performed by the recording and reproduction apparatus **300** is completed.

[0178] The order of recording the updated latest defect list is not limited to the above-described order of the latest header, the P' number of latest defect entries, and the latest anchor. As long as the header **121**, the N number of defect entries **122** through **125**, and the anchor **126** are located in this order in the defect list **112**, the control section **301** may request the recording and reproduction section **302** to record the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header in this order in each of the first through fourth defect management areas **104, 105, 108** and **109**, and the recording and reproduction section **302** may record the updated latest defect list in each of the first through fourth defect management areas **104, 105, 108** and **109** upon the request from the control section **301.**

[0179] Figure **5** shows a procedure of defect management processing for updating the latest defect list in the first example. The defect management processing is executed by the control section **301**. Hereinafter, each step of the procedure of defect management processing will be described.

[0180] Step S501: It is determined whether (a) another defect area exists in the data area **102**, (b) a defect area which was previously determined to be a defect area is currently a normal defect area, or (c) neither (a) nor (b) is the case. When it is determined that (a) another defect area exists in the data area **102** or that (b) the defect area is currently a normal defect area, the defect management processing advances to step S502. When it is determined that neither (a) nor (b) is the case, the defect management processing is terminated. Such a determination is, for example, performed when recording user data in the data area **102** or reproducing user data recorded in the data area **102**.

[0181] Step S502: The latest defect entries and the latest defect entry number P are updated. The P number of latest defect entries are updated to P' number of latest defect entries. The latest defect entry number P is updated to P'.

[0182] More specifically, when another defect area is determined to exist in the user area **106,** another defect entry is added to the latest defect list. Next, the latest defect entry number is increased by the number of the added defect entries ($P \neq P'$, $P < P'$).

[0183] When another defect is determined to exist in the spare area **107**, the substitute position information corresponding to the another defect area in the latest defect list is rewritten. The substitute position information corresponding to the another defect area is rewritten into substitute position information representing a portion other than the another defect area in the spare

area **107.** The latest defect entry number is not changed (P = P').

[0184] When an area which was previously determined to be a defect area is currently determined to be a normal defect area, the defect entry including the position information on the position of the defect area which was previously determined to be a defect area is deleted. Next, the latest defect entry number is decreased by the number of the deleted defect entries (i.e., the number of defect areas (number of sectors) currently determined to be normal) ($P \neq P'$, $P > P'$).

[0185] When the latest defect entries and the latest defect entry number P are updated, the defect management processing advances to step S503.

[0186] Step S503: The first and second latest update times information are each incremented by one. Then, the defect management processing advances to step S504.

[0187] Step S504: The latest defect list updated in steps S502 and S503 is recorded in the first defect management area **104** of the optical disc **100**. For example, the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor are recorded in the first defect management area **104** in this order. Then, the defect management processing advances to step S505. As long as the header **121**, the N number of defect entries **122** through **125**, and the anchor **126** are located in this order in the defect list **112**, the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header may be recorded in this order in the first defect management area **104**.

[0188] Step S505: It is determined whether or not the updated defect list has been recorded in all the defect management areas of the optical disc **100** (in this case, the first through fourth defect management areas **104, 105, 108** and **109**). When the updated defect list has been recorded in all the defect management areas of the optical disc **100**, the defect management processing is terminated. When the updated defect list has not been recorded in all the defect management areas of the optical disc **100,** the defect management processing returns to step S504.

[0189] As described above, the arrangement of the latest header, the P' number of latest defect entries and the latest anchor in the latest defect list is arbitrary. The updated latest defect list is recorded in each of the first through fourth defect management areas **104, 105, 108** and **109** of the optical disc **100** as follows. Such that the updated latest header is located at the position of the header **121**, the updated P' number of latest defect entries are located at the positions of the defect entries **122** through **125**, and the updated latest anchor is located at the position of the anchor **126**, the updated latest defect list is recorded in each of the first through fourth defect management areas **104, 105, 108** and **109** in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

[0190] In the above description, the updated latest defect list is recorded on the optical disc **100** shown in Figure **1** where the optical disc **100** has been subjected to defect management. Next, recording of the updated latest defect list on an optical disc in an initial state immediately after being shipped from the plant will be described.

[0191] An optical disc in an initial state is assumed to have the same structure as that shown in Figure **1** except that, for example, the defect list **112** (Figure 1) has no information. In such optical disc, neither a defect list identifier for identifying the defect list nor an anchor identifier for identifying the anchor of the defect list is recorded. Therefore, in the case where the latest defect list includes neither the latest defect list identifier nor the latest anchor identifier, the defect management processing of recording the latest defect list includes the process of recording the defect list identifier and the anchor identifier in addition to the process of recording the latest defect list in the defect management area. In the case where the latest defect list includes the latest defect list identifier and the latest anchor identifier, no detailed explanation will be given since the processing was described above with reference to Figure **5.**

[0192] The control section **301** requests the recording and reproduction section **302** to record the latest defect list stored in the storage section **303** in the defect management area of the optical disc and to record the inherent defect list identifier and the inherent anchor identifier, which are initially stored in the control section **301**, in a defect management area of the optical disc. More specifically, the inherent defect list identifier is recorded in the defect management area so as to be located at the start of the header **121**. The inherent anchor identifier is recorded in the defect management area so as to be located at the start of the anchor **126**. In this case, an arbitrary value is recorded as the latest defect entry number and as the latest defect entry of the latest defect list which respectively correspond to the defect entry number **132** and the first through Nth defect entries **122** through **125.** As the first update times information and as the second update times information, for example, 0 or 1 is recorded. The values to be recorded as the first and second update times information are arbitrary as long as the values are equal to each other and represent that recording has been performed on an optical disc in the initial state only once.

[0193] The method for recording the defect list identifier and the anchor identifier in the defect management area is not limited to the above-described method. For example, the inherent defect list identifier already stored in the control section **301** is given as the latest defect list identifier at the start of the latest header of the latest defect list stored in the storage section **303**. Similarly, the inherent anchor identifier already stored in the con-

trol section **301** is given as the latest anchor identifier at the start of the latest anchor of the latest defect list. As the defect management processing performed on an optical disc in the initial state, the latest defect list including the latest defect list identifier and the latest anchor identifier obtained in this manner may be recorded in the defect management area.

[0194] This process of defect management processing is performed in steps S504 and S505 in Figure **5.**

[0195] In the first example, it is accurately determined whether or not the defect management area has been updated normally. This will be described in three different cases of update. In the following explanation, the optical disc **100** is used.

(Specific example 1: when a defect entry is added)

[0196] Figure **6** shows data structures of a defect list in various states. Part (a) shows a data structure of a pre-update defect list. Part (b) shows a data structure of a defect list which was updated normally. Part (c) shows a data structure of a defect list which was not updated normally.

[0197] Figure **6** shows the case where another defect area (defect sector) is detected in the user area **106** and one defect entry is added. The addition of the defect entry is performed as described above with reference to Figures **3** and **5**.

[0198] Part (a) of Figure **6** shows a data structure before the defect list is updated. The defect list shown in part (a) is the same as the defect list **112** shown in Figure **1.** The defect list includes a first defect entry, ..., and an Nth defect entry. The defect entry number is N, and the content of each of the first update times information and the second update times information is M.

[0199] Part (b) of Figure **6** shows a data structure after the defect list is updated normally (one defect entry is added normally). When one defect entry is added normally to the defect list, the defect list includes the first defect entry, ..., the Nth defect entry, and an (N+1)th defect entry. The number of defect entries is increased by one from the state in part (a) of Figure **6**. The defect entry number is updated from N to N+1. The content of each of the first update times information and the second update times information is updated from M to M+1.

[0200] Following the addition of the defect entry, the position of the anchor is shifted toward the unused area by the size of the added defect entry from the position shown in part (a) of Figure **6**. The shifted position of the anchor is calculated as follows. The defect entry number (N+1) included in the header is multiplied by the size of one defect entry. The shifted position of the anchor is away toward the unused area from the end of the header by the multiplication result. At this point, the information which is read from the calculated position matches the value of the inherent anchor identifier of the control section **301**. Thus, it is confirmed that the anchor is read. In addition, the content of the first updated times information matches the content of the second updated times information. Thus, it can be determined that the defect list has been updated normally.

[0201] Part (c) of Figure **6** shows a datastructure of a defect data in the case where the update failed before the anchor is recorded. The failure occurs when, for example, the recording and reproduction apparatus **300** is turned off while the defect list is being updated. In part (c) of Figure **6**, the defect list includes the first defect entry, ..., and the Nth defect entry, like in part (a) of Figure **6**. Although the defect list includes the same defect entries as those of part (a) of Figure **6**, the defect entry number is updated from N to (N+1). The content of the first update times information is updated from M to (M+1). However, the content of the second update times information is M like in part (a) of Figure **6**. In this case, the anchor is not located at the position which is obtained by multiplying the defect entry number (N+1) included in the header by the size of one defect entry. The information which is read from the position calculated as the position of the anchor is padding data (=0 in part (c) of Figure **6**) which is recorded in the unused area and is meaningless information. The information which is read as the position of the anchor is different from the value of the inherent anchor identifier of the control section **301**. Thus, it is determined that the updating of the defect list failed.

(Specific example 2: when a defect entry is deleted)

[0202] Figure **7** shows data structures of a defect list in various states. Part (a) shows a data structure of a pre-update defect list. Part (b) shows a data structure of a defect list which was updated normally. Part (c) shows a data structure of a defect list which was not updated normally.

[0203] Figure **7** shows the case where a defect area which was previously determined to be a defect area is currently determined to be a normal defect area, and the defect entry including the position information on the position of the defect area which is currently determined to be the normal defect area is deleted. The deletion of the defect entry is performed as described above with reference to Figures **3** and **5**.

[0204] Part (a) of Figure **7** shows a data structure before the defect list is updated. The defect list shown in part (a) is the same as the defect list **112** shown in Figure **1**.

[0205] Part (b) of Figure **7** shows a data structure after the defect entry is deleted normally. When one defect entry is deleted normally from the defect list, the defect list includes the first defect entry, ..., and an (N-1)th defect entry. The number of defect entries is decreased by one from the state in part (a) of Figure 7. The defect entry number is updated from N to N-1. The content of each of the first update times information and the second update times information is updated from M to M+1.

[0206] Following the deletion of the defect entry, the

position of the anchor is shifted toward the header by the size of the deleted defect entry from the position shown in part (a) of Figure 7. The shifted position of the anchor is calculated as follows. The defect entry number (N-1) included in the header is multiplied by the size of one defect entry like in Specific example 1. The shifted position of the anchor is away toward the unused area from the end of the header by the multiplication result. At this point, the information which is read from the calculated position matches the value of the inherent anchor identifier of the control section **301**. Thus, it is confirmed that the anchor is read. In addition, the content of the first updated times information matches the content of the second updated times information. Thus, it can be determined that the defect list has been updated normally.

[0207] Part (c) of Figure **7** shows a data structure of a defect data in the case where the update failed before the anchor is recorded. The failure occurs when, for example, the recording and reproduction apparatus **300** is turned off while the defect list is being updated. In part (c) of Figure **7**, the defect list includes the first defect entry, ..., and the Nth defect entry, like in part (a) of Figure **7**. Although the defect list includes the same defect entries as those of part (a) of Figure **7,** the defect entry number is updated from N to (N-1). The content of the first update times information is updated from M to (M+1). However, the content of the second update times information is M like in part (a) of Figure **7**. In this case, the anchor is not located at the position which is obtained by multiplying the defect entry number (N-1) included in the header by the size of one defect entry. The information which is read from the position calculated as the position of the anchor is the Nth defect position information which is included in the Nth defect entry. The value of the inherent anchor identifier of the control section **301** is different from any of the defect list identifier, the defect entries, or the padding data as described above with reference to Figures **2A** through **2D**. Thus, it never occurs that the content of the Nth defect position information accidentally matches the value of the inherent anchor identifier, resulting in an erroneous determination that the defect list has been updated normally.

(Specific example 3: when a defect entry is changed)

[0208] Figure **8** shows data structures of a defect list in various states. Part (a) shows a data structure of a pre-update defect list. Part (b) shows a data structure of a defect list which was updated normally. Part (c) shows a data structure of a defect list which was not updated normally.

[0209] Figure **8** shows the case where another defect area exists in the spare area **107** which is used as the substitute area (substitute sector) for the defect area (defect sector) represented by the (N-1)th defect position information, and the substitute position information in the (N-1)th defect entry is changed. The change of the defect entry is performed as described above with reference to Figures **3** and **5**.

[0210] Part (a) of Figure **8** shows a data structure before the defect list is updated. The defect list shown in part (a) is the same as the defect list **112** shown in Figure **1**.

[0211] Part (b) of Figure **8** shows a data structure after the defect list is changed normally (after the substitute position information is changed normally) . Since no defect entry is added or deleted, the defect list includes the first defect entry, ..., and the Nth defect entry like in part (a) of Figure **8**. The number of defect entries is N like in part (a) of Figure **8**. The content of each of the first update times information and the second update times information is updated from M to M+1.

[0212] Accordingly, the position of the anchor after the update is the same as the position of the anchor before the update. The position of the anchor is calculated as follows. The defect entry number N included in the header is multiplied by the size of one defect entry. The position of the anchor is away toward the unused area from the end of the header by the multiplication result. At this point, the information which is read from the calculated position matches the value of the inherent anchor identifier of the control section **301**. Thus, it is confirmed that the anchor is read. In addition, the content of the first updated times information matches the content of the second updated times information. Thus, it can be determined that the defect list has been updated normally.

[0213] Part (c) of Figure **8** shows a data structure of a defect data in the case where the update failed before the anchor is recorded. The failure occurs when, for example, the recording and reproduction apparatus **300** is turned off while the defect list is being updated. In part (c) of Figure **8**, the defect list includes the first defect entry, ..., and the Nth defect entry, like in part (a) of Figure **8**. The defect entry number is N like in part (a) of Figure **8**. The content of the first update times information is updated from M to (M+1). However, the content of the second update times information is M like in part (a) of Figure **8**. In this case, the position which is obtained by multiplying the defect entry number N included in the header by the size of one defect entry is the correct position of the anchor. However, since the content of the first update times information is different from the content of the second update times information, it never occurs that the defect list is erroneously determined to have been updated normally.

[0214] In the first example, the header **121** includes the defect list identifier **131.** The header **121** is located at a physically specified position in the optical disc **100** and therefore does not need to include the defect list identifier **131**. Even without the defect list identifier **131**, the same effect as described in the first example can be provided.

[0215] As described above, according to the first example of the present invention, the information recording medium **100** includes the data area **102** for recording

user data, and the defect management areas **104, 105, 108** and **109** for recording a defect list used for managing N number of defect areas existing in the data area **102** (N is an integer satisfying $N \geq 0$). The defect list **112** includes the header **121,** the N number of defect entries respectively including the position information on the positions of the N number of defect areas, and the anchor **126.** The header **121,** the N number of defect areas, and the anchor **126** are located in this order in the defect list **112**.

[0216] Owing to such a structure, the size of the defect list **112** is variable. Since the size of the defect list **112** is varied in accordance with the number of detected defect areas (defect sectors), the size of the defect list **112** is decreased when the number of the defect areas is small. Namely, the defect list **112** is accommodated in a small ECC size (e.g., 1ECC size). When the size of the defect list **112** is small, the time required for recording the defect list **112** in the defect management area is shorter and the processing efficiency is improved. Even when a defect area exists in the remaining ECC blocks (unused area) of the defect management area other than the defect list **112**, that defect management area can be processed as a normal defect management area. Accordingly, data in the defect management area can be normally reproduced.

[0217] According to the first example of the present invention, the header **121** includes the defect list identifier **131** for identifying the defect list **112**, the first update times information **133** representing the number of times which the defect list **112** has been updated, and the defect entry number **132** representing the number of defect entries. The anchor **126** includes the anchor identifier **151** for identifying the anchor of the defect list **112,** and the second update times information **152** representing the number of times which the defect list **112** has been updated.

[0218] Owing to such a structure, it is not necessary to provide a header for each 1ECC size even when the size of the defect list **112** is not accommodated in 1ECC size. Thus, the processing efficiency of updating the defect list **112** is improved. Since the header is not interposed between the two defect entries, defect entries can be, for example, searched for, added and deleted easily.

[0219] The content of the anchor identifier **151** is different from any of the defect list identifier **131**, the defect entry number **132**, the first update times information **133**, the defect entries, or the second update times information **152**. As such, even when a defect entry is deleted, the information which is erroneously read as the anchor identifier **151** never matches the content of the inherent anchor identifier. Therefore, the defect list **112** is not erroneously determined to have been updated normally when it has not been updated normally.

(Example 2)

(1) Information recording medium

[0220] Figure **9** shows a data structure of an information recording medium **900** according to a second example of the present invention.

[0221] The information recording medium (optical disc) **900** may be, for example, a rewritable optical disc. The optical disc **900** is assumed to be subjected to error correction in units of 1ECC block. An ECC block is a unit of error correction in the field of optical discs. This size of one ECC block will be referred to as "1ECC size", hereinafter. It is assumed that the recording of information on the optical disc **900** and updating of the information on the optical disc **900** are performed in units of 1ECC block.

[0222] The data structure shown in Figure **9** is the structure of the optical disc **900** after position information on N number of defect areas in a defect management area is normally recorded (N is an integer satisfying $N \geq 0$). A defect area is, for example, a defect sector.

[0223] The optical disc **900** includes a data area **902** for recording user data, and a lead-in area **901** and a lead-out area **903** acting as buffer areas when a recording and reproduction apparatus (not shown) overruns by the movement of an optical head (not shown).

[0224] The data area **902** includes a user area **906** for recording user area and a spare area **907**. When there is a defect area (for example, a defect sector) in the user area **906,** the user data which is to be recorded in the defect area is recorded in the spare area **907** instead of a portion of the user area **906** corresponding to the defect area.

[0225] The lead-in area **901** includes a first defect management area **904** and a second defect management area **905** for recording defect management information used for managing a defect area existing in the data area **902**.

[0226] The lead-out area **903** includes a third defect management area **908** and a fourth defect management area **909** for recording defect management information used for managing a defect area existing in the data area **902**, like the lead-in area **901**.

[0227] The first defect management area **904**, the second defect management area **905**, the third defect management area **908**, and the fourth defect management area **909** are respectively located at physically specific positions in the optical disc **900**.

[0228] In the first defect management area **904**, the second defect management area **905**, the third defect management area **908** and the fourth defect management area **909**, the same information for defect management is recorded in multiplex. The reason for this is, as described above in the first example, that the information recorded in the first, second, third and fourth defect management areas **904, 905, 908,** and **909** cannot be a target of defect management. Even if some of the

first, second, third and fourth defect management areas **904, 905, 908,** and **909** have a defect area and the information recorded in the defect area cannot be reproduced, as long as at least one of the four defect management areas is defect-free, the defect management information recorded in that area can be normally reproduced. Accordingly, loss of the user data is prevented, which improves reliability. In the second example, the optical disc **900** includes the four defect management areas **904, 905, 908,** and **909,** but the number of defect management areas may be any number of one or more.

[0229] In the first defect management area **904**, a disc definition structure **911** and a defect list **912** for managing N number of defect areas existing in the data area **902** (N is an integer satisfying $N \geq 0$) are recorded.

[0230] The disc definition structure **911** is information representing the disc structure, for example, whether or not the disc **900** has been subjected to defect management. This information also includes information regarding the spare area **907.** The disc definition structure **911** is located at a physically specific position in the first defect management area **904.** The disc definition structure **911** has a prescribed size.

[0231] The defect list **912** includes a header **921**, a first defect entry **922,** a second defect entry **923,** ..., an (N-1)th defect entry **924,** an Nth entry **925,** and an anchor **927** located at a fixed position in the defect list **912**. The defect list **912** further includes an unused area **926,** unlike in the first example. The header **921**, the first through Nth entries **922** through **925**, and the anchor **927** are located in this order in the defect list **912**.

[0232] In the second example, it is assumed that the size of the defect list **912** is 4ECC. The size of the defect list **912** is not limited to 4ECC and is arbitrary.

[0233] The header **921** includes a defect list identifier **931** which represents that the area is the defect list **912,** a defect entry number **932** which represents the number of defect entries included in the defect list **912**, and first update times information **933** which represents the number of times which an updated defect list has been recorded in the first defect management area **904**. In Figure **9**, the defect entry number **932** is N (N is an integer satisfying $N \geq 0$), and the content of the first update times information **933** is M (M is an integer satisfying $M \geq 0$). The defect list identifier **931** may be located, for example, at the start of the header **921** shown in Figure **9**.

[0234] The header **921** is located at a physically specified position. In the second example, the header **921** is located at the start of the defect list **912**. The position of the header **921** in the defect list **912** is arbitrary as long as the header **921**, the first through Nth defect entries **922** through **925**, and the anchor **927** are located in this order in the defect list **912**.

[0235] In the case of the optical disc **900** shown in Figure **9**, the defect entry number **932** is N. Thus, the defect list **912** includes the first defect entry **922,** ..., and the Nth defect entry **925**. The first defect entry **922** includes first defect position information **941** which is position information showing the position of a defect area, and first substitute position information **942** which is position information showing the position of a part of the spare area **907** which is usable instead of the defect area. Likewise, the second defect entry **923** includes second defect position information and second substitute position information. The (N-1)th defect entry **924** and the Nth defect entry **925** also have substantially the same structure. Here, each of the first defect position information **941** and the first substitute position information **942** is generally a sector number.

[0236] The defect entries are generally located such that the defect position information included therein is in an ascending order. More specifically, when, for example, the defect position information is a sector number, defect position information having the smaller sector number is located in the first defect entry as the first defect position information **941**. After this, the defect entries are located in the order of the sector numbers. Defect position information having the larger sector number is located in the Nth defect entry **925** as Nth defect position information.

[0237] The defect entries in the defect list **912** do not need to be located in an ascending order. For example, the defect entries may be located such that the sector numbers are in a descending order. Alternatively, the defect entries may be located randomly.

[0238] In the unused area **926**, currently meaningless information is recorded. Generally, padding data **952** (for example, 0) is recorded in the unused area **926**. When a new defect area is detected in the user area **906**, a defect entry for managing the new defect area is added to the defect list **912.** As a result, the size of the unused area **926** is decreased by the size of the added defect entry.

[0239] The anchor **927** includes second update times information **951** which represents the number of times which the updated defect list has been recorded in the first defect management area **904**. In Figure **9**, the content of the second update times information **951** is M (M is an integer satisfying $M \geq 0$), and is the same as that of the first update times information **933.** As long as the first defect management area **904** is updated normally, the content of the first update times information **933** and the content of the second update times information **951** are identical to each other.

[0240] In this specification, the first and second update times information **933** and **951** represent the number of times which the updated defect list has been recorded in the first defect management area **904** (i.e., the number of times which the defect list **912** has been updated and recorded on the optical disc **900**). The first and second update times information **933** and **951** may represent the number of times which the defect list has been updated (i.e., the number of times which the defect list has been updated in the storage section described below). In the following description, the first and second

update times information **933** and **951** represent the number of times which the updated defect list has been recorded in the first defect management area **904**.

[0241] The anchor **927** is located at a fixed position in the defect list **912**, unlike in the first example. The anchor **927** is preferably located which is determined based on the position of the header **921**. In the second example, the anchor **927** is located at the position of the end of the defect list **912**, i.e., at the end of the first defect management area **904**. Since the size of the defect list **912** is fixed at 4ECC, the anchor **927** is located at the end of the fourth ECC block from the start of the defect list **912**. However, as long as the header **921,** the 1st through Nth defect entries **922** through **925**, and the anchor **927** are located in the defect list **912** in this order, the anchor **927** may be fixed at an arbitrary position in the defect list **912**.

[0242] In the optical disc **900** in the second example, the anchor **927** is located at a physically fixed position in the defect list **912**. The header **921** includes the first update times information **933**, and the anchor **927** includes the second update times information **951**. Since the position of the anchor **927** is fixed, the content of the first update times information **933** and the content of the second update times information **951** are compared with each other without fail. Accordingly, it can be easily determined whether or not the defect list **912** has been updated normally.

[0243] The following description will be made with the premise that the optical disc **900** has the data structure shown in Figure **9**.

(2) Reproduction/recording (update)

[0244] The recording and reproduction apparatus **300** shown in Figure **3** is used for recording information on the optical disc **900** according to the second example and/or reproducing information recorded on the optical disc **900**. Unlike in the first example, the control section **301** in the second example has only an inherent defect list identifier for identifying the defect list **912** in the optical disc **900** stored thereon. The content (value) of the inherent defect list identifier is correct and is not rewritable. The description of the recording and reproduction apparatus **300** shown in Figure **3** is provided in the first example and will not be repeated here.

(2-1) Defect management processing for specifying the latest defect list

[0245] Next, with reference to Figure **3**, the operation of defect management processing for specifying the latest defect list performed by the recording and reproduction apparatus **300** will be described.

[0246] The control section **301** executes the defect management processing. The control section **301** follows the procedure of the defect management processing to request the recording and reproduction section **302** to reproduce the information of the disc definition structure **911** located at the start of the first defect management area **904** and store the reproduced information from the disc definition structure **911** in the storage section **303**.

[0247] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the information of the disc definition structure **911** from the optical disc **900** and stores the information in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the information of the disc definition structure **911** has been completed.

[0248] Upon receiving the report from the recording and reproduction section **302**, the control section **301** checks whether or not the optical disc **900** has been subjected to defect management, based on the information of the disc definition structure **911** stored in the storage section **303**.

[0249] When confirming that the optical disc **900** has been subjected to defect management, the control section **301** requests the recording and reproduction section **302** to reproduce the header **921** located at a fixed position of the defect list **912** (in the example of Figure **9,** at the start of the defect list **912**) recorded in the first defect management area **904** and store the reproduced header **921** in the storage section **303**.

[0250] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the header **921** located at the start of the defect list **912** recorded in the first defect management area **904** and store the reproduced header **921** in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the header **921** has been completed.

[0251] Upon receiving the report from the recording and reproduction section **302**, the control section **301** compares the content of the inherent defect list identifier initially stored in the control section **301** with the content of the defect list identifier **931** included in the header **921** stored in the storage section **303** to check whether or not the stored information is the header **921** in the defect list **912**.

[0252] When the two contents compared match each other, the control section **301** determines that the stored information is the header **921** in the defect list **912** and proceeds with the defect management processing. When the two contents compared do not match each other, the control section **301** determines that updating of the first defect management area **904** failed (abnormal defect management area) and terminates the defect management processing. The two contents compared do not match each other when, for example, there is a defect area in the first defect management area **904** and thus information cannot be read therefrom.

[0253] In order to confirm the content of the first update times information **933** and the content of the second update times information **951** in the first defect man-

agement area **904**, the control section **301** requests the recording and reproduction section **302** to reproduce the anchor **927** located at the fixed position in the defect list **912** (in Figure **9**, at the end of the fourth ECC block from the start of the defect list **912**) and store the reproduced anchor **927** in the storage section **303**.

[0254] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the anchor **927** located at the designated position in the defect list **912** and stores the reproduced anchor **927** in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the anchor **927** has been completed.

[0255] The control section **301** compares the content of the first update times information **933** included in the header **921** with the content of the second update times information **951** included in the anchor **927** stored in the storage section **303**.

[0256] When the two contents compared match each other, the control section **301** determines that the first defect management area **904** has been updated normally, and proceeds with the defect management processing.

[0257] When the two contents compared do not match each other, the control section **301** determines that updating of the first defect management area **904** failed (abnormal defect management area) and terminates the defect management processing. The two contents compared do not match each other when, for example, the recording and reproduction apparatus **300** is turned off while the first through Nth defect entries **922** through **925** in the defect list **912** are being updated. In this case, the content of the first update times information **933** included in the header **921** does not match the content of the second update times information **951** included in the anchor **927**.

[0258] The control section **301** performs substantially the same processing for each of the second defect management area **905,** the third defect management area **908** and the fourth defect management area **909.**

[0259] After checking whether or not each of the first through fourth defect management areas **904, 905, 908** and **909** is a normal defect management area, the control section **301** specifies the latest defect management area among the defect management areas which have been determined to be normal, as follows. The control section **301** makes a comparison of the first update times information **933** recorded in the defect management areas which have been determined to be normal, and specifies the defect management area having the largest number of updates as the latest defect management area. The defect list recorded in the specified latest defect management area is specified as the latest defect list.

[0260] The second update times information **951** included in the anchor **927** may be used for specifying the latest defect management area instead of the first update times information **933**.

[0261] The control section **301** requests the recording and reproduction section **302** to reproduce the defect list recorded in the specified latest defect management area and store the reproduced defect list in the defect list area saved in the storage section **303**.

[0262] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the defect list recorded in the specified latest defect management area and stores the reproduced defect list in the defect list area in the storage section **303**. The recording and reproduction section **302** reports to the control section **301** that the reproduction and storage of the defect list has been completed.

[0263] Thus, the operation of defect management processing for specifying the latest defect list performed by the recording and reproduction apparatus **300** is completed.

[0264] Using the specified latest defect list, the user data recorded in the data area **902**, for example, can be reproduced. In this case, the control section **301** requests the recording and reproduction section **302** to reproduce the user data based on the latest defect list and store the reproduced user data in the storage section **303**.

[0265] Upon the request from the control section **301**, the recording and reproduction section **302** reproduces the user data from the data area **902** and stores the reproduced user data in the storage section **303**.

[0266] Information recording may be performed using the specified latest defect list.

[0267] Figure **10** shows a procedure of defect management processing for specifying the latest defect list in the second example. The defect management processing is executed by the control section **301**. Hereinafter, each step of the procedure of defect management processing will be described. The procedure of defect management processing is started after it is confirmed that the optical disc **900** has been subjected to defect management. Whether or not the optical disc **900** has been subjected to defect management is determined based on the disc definition structure **911** in the optical disc **900**.

[0268] Step S1001: The defect list identifier **931,** the defect entry number **932** and the first update times information **933** included in the header **921** are reproduced. The content of the reproduced defect list identifier **931** is compared with the content of the inherent defect list identifier. The inherent defect list identifier identifies the defect list **912** in the optical disc **900**. The inherent defect list identifier has a correct value which is not rewritable. The inherent defect list identifier may be initially stored in the control section **301.** When the two contents compared match each other, the defect management processing advances to step S1002. When the two contents compared do not match each other, the defect management processing advances to step S1003.

[0269] Step S1002: When the content of the defect list identifier **931** and the content of the inherent defect list identifier are determined to match each other in step S1001, the reproduced information is determined to be the header **921** in the defect list **912**. The anchor **927** located at a fixed position (in Figure **9**, at the position of the fourth ECC block from the start of the defect list **912**) is reproduced. The content of the first update times information **933** included in the header **921** is compared with the content of the second update times information **951** included in the anchor **927**. When the two contents compared are determined to match each other, the defect management processing advances to step S1004. When the two contents compared are determined not to match each other, the defect management processing advances to step S1003.

[0270] Step S1003: When the content of the defect list identifier **931** and the content of the inherent defect list identifier are determined not to match each other in step S1001, or when the content of the first update times information **933** and the content of the second update times information **951** are determined not to match each other in step S1002, updating of the first defect management area **904** is determined to have failed (abnormal defect management area), and the defect management processing for the first defect management area **904** is terminated. The defect management processing advances to step S1005.

[0271] Step S1004: When the content of the first update times information **933** and the content of the second update times information **951** are determined to match each other in step S1002, the first defect management area **904** is determined to have been updated normally. Then, the defect management processing advances to step S1005.

[0272] Step S1005: It is determined whether or not the operations in steps S1001 through S1004 have been performed for all the defect management areas in the optical disc **900**. When the operations in steps S1001 through S1004 have not been performed for all the defect management areas, the defect management processing returns to step S1001. When the operations in steps S1001 through S1004 have been performed for all the defect management areas, the defect management processing advances to step S1006.

[0273] Step S1006: The latest defect list is specified. More specifically, the latest defect management area among the defect management areas determined to be normal is specified, as follows. A comparison is made of the first update times information (or the second update times information) recorded in the defect management areas determined to be normal, and the defect management area having the largest number of updates is specified as the latest defect management area. The defect list recorded in the specified latest defect management area is specified as the latest defect list.

[0274] When the latest defect list of the optical disc **900** is specified by steps S1001 through S1006, the defect management processing is completed. Using the latest defect list obtained in step S1006, the user data recorded in the data area **902**, for example, can be reproduced.

(2-2) Defect management processing for updating the latest defect list

[0275] Returning to Figure **3**, the operation of defect management processing for updating the latest defect list performed by the recording and reproduction apparatus **300** will be described. In the following example, the defect list is updated when another defect area is detected while the user data is being recorded in the data area **902** of the optical disc **900**, or when a portion of the user area **906** which was previously determined to be a defect area is determined to be a normal defect area while the user data recorded in the data area **902** is being reproduced. Throughout this specification, a "normal defect area" is defined to mean an area which was previously determined to be a defect area but currently has no defect and allows information to be recorded therein and/or allows information therein to be reproduced. An area which was previously determined to be a defect area is currently determined to be a normal defect area when, for example, the defect is caused by dust or stain such as a fingerprint on the surface of the optical disc. In this case, when the user cleans the surface of the optical disc to remove the dust or stain, the area in which the dust or stain existed (i.e., the area which was previously determined to be a defect area) is currently determined to be a normal area usable for recording/reproduction.

[0276] The storage section **303** stores the latest defect list. The latest defect list may be located in the defect list area in the storage section **303**. The latest defect list includes the latest header, P number of latest defect entries (P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$), and the latest anchor. The latest header, the P number of latest defect entries, and the latest anchor are located in the latest defect list in this order. The latest header is located at a fixed position in the latest defect list. The latest anchor is also located at a fixed position in the latest defect list. The latest header includes the latest defect list identifier, the first latest update times information and the latest defect entry number P. The content of the latest defect list identifier is always the same as that of the inherent defect list identifier stored in the control section **301**. The latest anchor includes the second latest update times information which has the same content as that of the first latest update times information. It is assumed that the P number of latest defect entries are arranged in an ascending order of the defect position information (defect sector numbers). The latest defect list may include an unused area. It is not always necessary that the latest header includes the latest defect list identifier.

[0277] The above-described arrangement of the lat-

est header and the P number of latest defect entries and the latest anchor is merely an example. The arrangement of the latest header and the P number of latest defect entries and the latest anchor in the latest defect list is arbitrary.

[0278] The control section **301** executes the defect management processing. The control section **301** requests the recording and reproduction section **302** to determine whether (a) another defect area exists in the data area **902**, (b) a defect area which was previously determined to be a defect area is currently a normal defect area, or (c) neither (a) nor (b) is the case. Whether or not another defect area exists in the data area **902** is determined by, for example, comparing a signal obtained by reproducing data immediately after user data is recorded with a signal representing user data to be recorded. When these signals match each other, the user data is determined to have been normally recorded in the data area **902**. When these signals do not match each other, it is determined that the user data has not been normally recorded in the data area **902** and another defect area exists in the data area **902**.

[0279] When determining that another defect area exists in the data area **902** or that the area which was previously determined to be a defect area is currently a normal defect area, the control section **301** updates the latest defect list stored in the storage section **303.**

[0280] Specific procedures of updating the latest defect list will be described. There are three cases of updating the latest defect list, namely, (i) addition of a defect entry, (ii) deletion of a defect entry; and (iii) change of a defect entry. Each of these cases will be described one by one.

(i) Addition of a defect entry

[0281] When it is determined that another defect area exists in the user area **906**, a defect entry including the position information on the position of the another defect area is added to the latest defect list. Based on the defect position information on the detected defect area, the control section **301** determines the position of the defect entry to be added. The control section **301** shifts the other defect entries and the latest anchor existing subsequent to the determined position toward the unused area, and adds the defect entry including the position information on the another defect area at the determined position. As a result, the P number of latest defect entries are updated to P' number of latest defect entries ($P \neq P'$, $P < P'$).

[0282] Following the addition of the defect entry, the control section **301** updates the latest defect entry number from P into P'. In this case, the latest defect entry number is increased by the number of the added defect entries (i.e., by the number of the detected defect sectors).

[0283] After the P number of latest defect entries and the latest defect entry number P are updated, the control section **301** increments, by one, the content of the first latest update times information included in the latest header and the content of the second latest update times information included in the latest anchor.

(ii) Deletion of a defect entry

[0284] When an area which was previously determined to be a defect area is currently determined to be a normal defect area, the control section **301** deletes the defect entry including the position information on the area determined to be the normal defect area. The control section **301** then shifts the defect entries located subsequent to the deleted defect entry toward the latest header by the size of the deleted defect entry. The unused area is expanded by the size of the deleted defect entry, and the control section **301** records padding data (for example, 0) in the expanded portion of the unused area. As a result, the P number of latest defect entries are updated to P' number of latest defect entries ($P \neq P'$, $P > P'$).

[0285] Following the deletion of the defect entry, the control section **301** updates the latest defect entry number included in the latest header from P into P'. In this case, the latest defect entry number is decreased by the number of the deleted defect entries (i.e., by the number of the defect sectors determined to be normal).

[0286] After the P number of latest defect entries and the latest defect entry number P are updated, the control section **301** increments, by one, the content of the first latest update times information included in the latest header and the content of the second latest update times information included in the latest anchor.

(iii) Change of a defect entry

[0287] The operation in this case is the same as the operation described in the first example, and will not be repeated here.

[0288] The operations of (i) through (iii) are performed by the control section **301** for the latest defect list stored in the storage section **303**. As in the first example, in the case where the first and second update times information **933** and **951** represent the number of times which the updated latest defect list has been recorded in the first defect management area **904**, the first and second latest update times information may each be incremented by one only once before the updated latest defect list is recorded in the first defect management area **904.** By contrast, in the case where the first and second update times information **933** and **951** represent the number of times which the latest defect list has been updated in the storage section **303**, the first and second latest update times information may be incremented by one each time the latest defect entries and the latest defect entry number are updated.

[0289] The control section **301** requests the recording and reproduction section **302** to record the latest defect

list updated in the storage section **303** in the first defect management area **904** of the optical disc **900**. For example, the control section **301** requests the recording and reproduction section **302** to record the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor in the first defect management area **904** in this order.

[0290] Upon the request from the control section **301**, the recording and reproduction section **302** records the updated latest defect list in the first defect management area **904**. The updated defect list replacing the defect list **912** is recorded in the first defect management area **904** in the order of the latest header replacing the header **921**, the latest defect entries replacing the first through Nth defect entries **922** through **925**, and the latest anchor replacing the anchor **927**. The recording and reproduction section **302** reports to the control section **301** that the recording of the updated latest defect list in the first defect management area **904** has been completed. Unlike in the first example, the anchor **927** is located at the fixed position, i.e., at the end of the fourth ECC block from the start of the defect list **912** in the optical disc **900** in the second example. Therefore, even when the total size of the header **921** and the defect entries in the defect list **912** is accommodated in 1ECC size, data of at least two ECC blocks, i.e. , the data for the first ECC block and the data for the fourth ECC block need to be recorded.

[0291] The control section **301** requests the recording and reproduction section **302** to record the latest defect list updated in the storage section **303** in each of the second through fourth defect management areas **905, 908** and **909**. More specifically, again, the control section **301** requests the recording and reproduction section **302** to record the updated latest header, the updated latest defect entries, and the updated latest anchor in this order in the second through fourth defect management areas **905, 908** and **909**.

[0292] Upon the request from the control section **301**, the recording and reproduction section **302** records the updated latest defect list in each of the second through fourth defect management areas **905, 908** and **909**.

[0293] Thus, the operation of defect management processing for updating the latest defect list performed by the recording and reproduction apparatus **300** is completed.

[0294] The order of recording the updated latest defect list is not limited to the above-described order of the latest header, the P' number of latest defect entries, and the latest anchor. As long as the header **921**, the N number of defect entries **922** through **925**, and the anchor **927** are located in this order in the defect list **912**, the control section **301** may request the recording and reproduction section **302** to record the updated latest anchor, the P' number of latest defect entries, and the latest header in this order in each of the first through fourth defect management areas **904, 905, 908** and **909**, and the recording and reproduction section **302** may record the updated latest defect list in each of the first through fourth defect management areas **904, 905, 908** and **909** upon the request from the control section **301**.

[0295] Returning to Figure **5**, a procedure of defect management processing for updating the latest defect list in the second example will be described. The defect management processing is executed by the control section **301.** The operations in steps S501 through S503 and S505 are substantially the same as those of the first example, and will not be repeated here.

[0296] Step S504: The updated latest defect list is recorded in the first defect management area **904** of the optical disc **900**. For example, the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor are recorded in the first defect management area **904** in this order. As long as the header **921**, the N number of defect entries **922** through **925**, and the anchor **927** are located in this order in the defect list **912**, the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header may be recorded in this order in the first defect management area **904**. In the optical disc **900**, the anchor **927** is located at the fixed position in the defect list **912** (in Figure **9**, at the end of the fourth ECC block from the start of the defect list **912**). Therefore, even when the total size of the header **921** and the defect entries in the defect list **912** is accommodated in 1ECC size, data of at least two ECC blocks, i.e. , the data for the first ECC block and the data for the fourth ECC block are recorded.

[0297] As described above, the arrangement of the latest header, the P' number of latest defect entries and the latest anchor in the latest defect list is arbitrary. The updated latest defect list is recorded in each of the first through fourth defect management areas **904, 905, 908** and **909** of the optical disc **900** as follows. Such that the updated latest header is located at the position of the header **921**, the updated P' number of latest defect entries are located at the positions of the defect entries **922** through **925**, and the updated latest anchor is located at the position of the anchor **927**, the updated latest defect list is recorded in each of the first through fourth defect management areas **904, 905, 908** and **909** in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

[0298] In the above description, the updated latest defect list is recorded on the optical disc **900** shown in Figure **9** where the optical disc **900** has been subjected to defect management. Next, recording of the updated latest defect list on an optical disc in an initial state immediately after being shipped from the plant will be described.

[0299] An optical disc in an initial state is assumed to have the same structure as that shown in Figure **9** except that, for example, the defect list **912** (Figure **9**) has

no information. In such optical disc, no defect list identifier for identifying the defect list is recorded. Therefore, in the case where the latest defect list does not include the latest defect list identifier, the defect management processing of recording the latest defect list includes the process of recording the defect list identifier in addition to the process of recording the latest defect list in the defect management area. In the case where the latest defect list includes the latest defect list identifier, no detailed explanation will be given since the processing was described above with reference to Figure **5**.

[0300] The control section **301** requests the recording and reproduction section **302** to record the latest defect list stored in the storage section **303** in the defect management area of the optical disc and to record the inherent defect list identifier, which is initially stored in the control section **301**, in the defect management area of the optical disc. More specifically, the inherent defect list identifier is recorded in the defect management area so as to be located at the start of the header **921**. In this case, an arbitrary value is recorded as the latest defect entry number and as the latest defect entry of the latest defect list which respectively correspond to the defect entry number **932** and the first through Nth defect entries **922** through **925**. As the first update times information and as the second update times information, for example, 0 or 1 is recorded. The values to be recorded as the first and second update times information are arbitrary as long as the values are equal to each other and represent that recording has been performed on an optical disc in the initial state only once.

[0301] The method for recording the defect list identifier in the defect management area is not limited to the above-described method. For example, the inherent defect list identifier already stored in the control section **301** is given as the latest defect list identifier at the start of the latest header of the latest defect list stored in the storage section **303.** As the defect management processing performed on an optical disc in the initial state, the latest defect list including the latest defect list identifier obtained in this manner may be recorded in the defect management area.

[0302] This process of defect management processing is performed in steps S504 and S505 in Figure **5.**

[0303] In the second example, it is accurately determined whether or not the defect management area has been updated normally. This will be described below. In the following explanation, the optical disc **900** is used.

(Specific example 1: when a defect entry is added)

[0304] Figure **11** shows data structures of a defect list in various states. Part (a) shows a data structure of a pre-update defect list. Part (b) shows a data structure of a defect list which was updated normally. Part (c) shows a data structure of a defect list which was not updated normally.

[0305] Figure **11** shows the case where another defect area (defect sector) is detected in the user area **906** and one defect entry is added. The addition of the defect entry is performed as described above with reference to Figures **3** and **5**.

[0306] Part (a) of Figure **11** shows a data structure before the defect list is updated. The defect list shown in part (a) is the same as the defect list **912** shown in Figure **9**. The defect list includes a first defect entry, ..., and an Nth defect entry. The defect entry number is N, and the content of each of the first update times information and the second update times information is M.

[0307] Part (b) of Figure **11** shows a data structure after the defect list is updated normally (one defect entry is added normally). When one defect entry is added normally to the defect list, the defect list includes the first defect entry, ..., the Nth defect entry, and an (N+1)th defect entry. The number of defect entries is increased by one from the state in part (a) of Figure **11**. The defect entry number is updated from N to N+1. The content of each of the first update times information and the second update times information is updated from M to M+1.

[0308] Following the addition of the defect entry, the size of the unused area is decreased by the size of the added defect entry like Specific example 1, but the position of the anchor is fixed. The content of the first updated times information matches the content of the second updated times information. Thus, it can be determined that the defect list has been updated normally.

[0309] Part (c) of Figure **11** shows a data structure of a defect data in the case where the update failed before the anchor is recorded. The failure occurs when, for example, the recording and reproduction apparatus **300** is turned off while the defect list is being updated. In part (c) of Figure **11**, the defect list includes the first defect entry, ..., and the Nth defect entry, like in part (a) of Figure **11**. Although the defect list includes the same defect entries as those of part (a) of Figure **11**, the defect entry number is updated from N to (N+1). The content of the first update times information is updated from M to (M+1). However, the content of the second update times information is M like in part (a) of Figure **11**. Since the content of the first updated times information does not match the content of the second updated times information, it is determined that the updating of the defect list failed.

[0310] In the case where a defect entry is changed or a defect entry is deleted, it can be determined whether or not the defect list has been updated normally by comparing the content of the first update times information and the content of the second update times information in substantially the same manner.

[0311] In the second example, the anchor **927** includes only the second update times information **951**. As in the first example, the anchor **927** may also include an anchor identifier for identifying the anchor in the defect list **912**. In this case also, the same effect as described in the second example can be provided.

[0312] In the second example, the header **921** in-

cludes the defect list identifier **931**. The header **921** is located at a physically specified position in the optical disc **900** and therefore does not need to include the defect list identifier **931**. Even without the defect list identifier **931**, the same effect as described in the second example can be provided.

[0313] As described above, according to the second example of the present invention, the information recording medium **900** includes the data area **902** for recording user data, and the defect management areas **904, 905, 908** and **909** for recording a defect list used for managing N number of defect areas existing in the data area **902** (N is an integer satisfying $N \geq 0$). The defect list **912** includes the header **921,** the N number of defect entries respectively including the position information on the positions of the N number of defect areas, and the anchor **927** located at a fixed position in the defect list **912.** The header **921** includes the first update times information **933**, and the anchor **927** includes the second update times information **951**.

[0314] Since the anchor **927** is located at the fixed position, other information is never erroneously reproduced as the anchor **927**. Namely, the content of the first update times information **933** and the content of the second update times information **951** can be compared with each other without fail. Accordingly, it can easily be determined whether or not the defect list **912** has been updated normally.

[0315] Again, since the anchor **927** is located at the fixed position, it is not necessary to calculate the position of the anchor **927** and check whether or not the anchor **927** is located at the calculated position as is necessary in the first example, in order to reproduce the anchor **927**. Therefore, the processing of defect management can be simplified and improved in speed.

[0316] It is not necessary to provide a header for each 1ECC size even when the size of the defect list **912** is not accommodated in 1ECC size. Thus, the processing efficiency of updating the defect list **912** is improved. Since the header is not interposed between the two defect entries, defect entries can be, for example, searched for, added and deleted easily.

[0317] As described above, an information recording medium according to the present invention includes a data area for recording user data and a defect management area for recording a defect list used for managing N number of defect areas (N is an integer satisfying $N \geq 0$) existing in the data area. The defect list includes a header, N number of defect entries respectively including the position information on the positions of the N number of defect areas, and an anchor. The header, the N number of defect entries, and the anchor are located in this order in the defect list. Owing to such a structure, the size of the defect list is variable, and therefore the processing speed is improved in accordance with the size of the defect list.

[0318] With the information recording medium according to the present invention, the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of defect entries. The anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated. It is not necessary to provide a header for each 1ECC size even when the size of the defect list is not accommodated in 1ECC size. Thus, the processing efficiency of updating the defect list is improved. Since the header is not interposed between the two defect entries, defect entries can be, for example, searched for, added and deleted easily.

[0319] The content of the anchor identifier is different from any of the defect list identifier, the defect entry number, the first update times information, the defect entries, or the second update times information. As such, even when a defect entry is deleted, the information which is erroneously read as the anchor identifier never matches the content of the inherent anchor identifier. Therefore, the defect list is not erroneously determined to have been updated normally when it has not been updated normally.

[0320] Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

Claims

1. An information recording medium, comprising:

a data area for recording user data, and
a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$;

wherein:

the defect list includes:

a header located at a fixed position in the defect list,
N number of defect entries respectively including position information on positions of the N number of defect areas, and
an anchor;

the header, the N number of defect entries, and the anchor are located in this order in the defect list;
the header includes:

a defect list identifier for identifying the defect list,
first update times information representing the number of times which the defect list has been updated, and
a defect entry number representing the number of the N number of defect entries; and

the anchor includes:

an anchor identifier for identifying the anchor of the defect list, and
second update times information representing the number of times which the defect list has been updated.

2. An information recording medium according to claim 1, wherein the defect list includes at least two blocks, and the defect list is recorded in units of one block.

3. A recording apparatus for recording information on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor; the header, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated;

the recording apparatus comprising:

a recording section for recording the information on the information recording medium,
a storage section for storing the information to be recorded on the information recording medium, and a latest defect list, and
a control section for controlling execution of defect management processing which is performed using the recording section and the storage section;

wherein:

the latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$;
the latest header includes first latest update times information and a latest defect entry number P;
the latest anchor includes second update times information having a content identical to that of the first update times information; and
the defect management processing includes the steps of:

(a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case,
(b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P';
(c) incrementing, by one, each of the first latest update times information and the second latest update times information, and
(d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

4. A recording apparatus to claim 3, wherein the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

5. A recording apparatus according to claim 4, wherein the step (b) includes the step of, when it is determined in the step (a) that another defect area exists in the data area, adding another defect entry to the latest defect list.

6. A recording apparatus according to claim 4, wherein the step (b) includes the step of, when it is determined in the step (a) that a normal defect area exists among the N number of defect areas, deleting a defect entry including position information on a position of the normal defect area from the P number of latest defect entries.

7. A recording apparatus according to claim 4, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the control section controls execution of the step (d) for the another defect management area.

8. A recording apparatus according to claim 3, wherein the step (b) includes the step of, when it is determined in the step (a) that another defect area exists in the data area, adding another defect entry to the latest defect list.

9. A recording apparatus according to claim 3, wherein the step (b) includes the step of, when it is determined in the step (a) that a normal defect area exists among the N number of defect areas, deleting a defect entry including position information on a position of the normal defect area from the P number of latest defect entries.

10. A recording apparatus according to claim 3, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the control section controls execution of the step (d) for the another defect management area.

11. A recording method for recording information on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor; the header, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated;

wherein the recording is performed using a latest defect list; the latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$; the latest header includes the first update times information and a latest defect entry number P; and the latest anchor includes second update times information having a content identical to that of the first update times information;

the recording method comprising the steps of:

(a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case,

(b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P';

(c) incrementing, by one, each of the first latest update times information and the second latest update times information, and

(d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

12. A recording method to claim 11, wherein the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updatedp' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

13. A recording method according to claim 12, wherein the step (b) includes the step of, when it is determined in the step (a) that another defect area exists in the data area, adding another defect entry to the latest defect list.

14. A recording method according to claim 12, wherein the step (b) includes the step of, when it is determined in the step (a) that a normal defect area exists among the N number of defect areas, deleting a defect entry including position information on a position of the normal defect area from the P number of latest defect entries.

15. A recording method according to claim 12, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the control section controls execution

of the step (d) for the another defect management area.

16. A recording method according to claim 11, wherein the step (b) includes the step of, when it is determined in the step (a) that another defect area exists in the data area, adding another defect entry to the latest defect list.

17. A recording method according to claim 11, wherein the step (b) includes the step of, when it is determined in the step (a) that a normal defect area exists among the N number of defect areas, deleting a defect entry including position information on a position of the normal defect area from the P number of latest defect entries.

18. A recording method according to claim 11, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the control section controls execution of the step (d) for the another defect management area.

19. A reproduction apparatus for reproducing information recorded on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor; the header located at a fixed position in the defect list, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated;

the reproduction apparatus comprising:

a reproduction section for reproducing the information recorded on the information recording medium,

a storage section for storing the reproduced information, and

a control section for controlling execution of defect management processing which is performed using the reproduction section and the storage section, the control section having an inherent defect list identifier for identifying the defect list and an inherent anchor identifier for identifying the anchor of the defect list;

wherein:

the defect management processing includes the steps of:

(a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of the inherent defect list identifier matches a content of the reproduced defect list identifier,

(b) calculating a position of the anchor in the defect list using the reproduced defect entry number when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier,

(c) reproducing the anchor identifier and the second update times information based on the calculated position of the anchor, and determining whether or not a content of the inherent anchor identifier matches a content of the reproduced anchor identifier,

(d) determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (c) that the content of the inherent anchor identifier matches the content of the reproduced anchor identifier, and

(e) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (d) that the content of the first update times information matches the content of the second update times information.

20. A reproduction apparatus according to claim 19, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein:

the control section controls execution of the defect management processing for the another defect management area; and

the step (e) includes the steps of:

(e_1) performing the steps (a) through (d) for the another defect management area, and
(e_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

21. A reproduction method for reproducing information recorded on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor; the header located at a fixed position in the defect list, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes an anchor identifier for identifying the anchor of the defect list, and second update times information representing the number of times which the defect list has been updated;

the reproduction method comprising the steps of:

(a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of an inherent defect list identifier for identifying the defect list matches a content of the reproduced defect list identifier,
(b) calculating a position of the anchor in the defect list using the reproduced defect entry number when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier,
(c) reproducing the anchor identifier and the second update times information based on the calculated position of the anchor, and determining whether or not a content of an inherent anchor identifier for identifying the anchor of the defect list matches a content of the reproduced anchor identifier,
(d) determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (c) that the content of the inherent anchor identifier matches the content of the reproduced anchor identifier, and
(e) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (d) that the content of the first update times information matches the content of the second update times information.

22. A reproduction method according to claim 21, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein:

the step (e) includes the steps of:

(e_1) performing the steps (a) through (d) for the another defect management area, and
(e_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

23. An information recording medium, comprising:

a data area for recording user data, and
a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$;

wherein:

the defect list includes:

a header located at a fixed position in the defect list,
N number of defect entries respectively including position information on positions of the N number of defect areas, and
an anchor located at a fixed position in the defect list;

the header, the N number of defect entries, and the anchor are located in this order in the defect list;
the header includes:

a defect list identifier for identifying the defect list,
first update times information representing the number of times which the defect list has been updated, and
a defect entry number representing the number of the N number of defect entries; and

the anchor includes second update times information representing the number of times which the defect list has been updated.

24. An information recording medium according to claim 23, wherein the defect list includes at least two blocks, and the defect list is recorded in units of one block.

25. A recording apparatus for recording information on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list; the header, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes second update times information representing the number of times which the defect list has been updated;

the recording apparatus comprising:

a recording section for recording the information on the information recording medium,
a storage section for storing the information to be recorded on the information recording medium, and a latest defect list, and
a control section for controlling execution of defect management processing which is performed using the recording section and the storage section;

wherein:

the latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$;
the latest header includes first latest update times information and a latest defect entry number P;
the latest anchor includes second update times information having a content identical to that of the first update times information; and
the defect management processing includes the steps of:

(a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case,
(b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P';
(c) incrementing, by one, each of the first latest update times information and the second latest update times information, and
(d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

26. A recording apparatus to claim 25, wherein the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updatedp' number of latest defect entries, and the updated latest header.

27. A recording apparatus according to claim 26, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the control section controls execution of the step (d) for the another defect management area.

28. A recording apparatus according to claim 25, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the control section controls execution of the step (d) for the another defect management area.

29. A recording method for recording information on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect

list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list; the header, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes second update times information representing the number of times which the defect list has been updated;

wherein the recording is performed using a latest defect list; the latest defect list includes a latest header, P number of latest defect entries, and a latest anchor, wherein P is an integer satisfying $P \geq 0$ where $P = N$ or $P \neq N$; the latest header includes the first update times information and a latest defect entry number P; and the latest anchor includes second update times information having a content identical to that of the first update times information;

the recording method comprising the steps of:

(a) determining (i) whether another defect area exists in the data area, (ii) whether a normal defect area exists among the N number of defect areas, or (iii) neither (i) nor (ii) is the case,

(b) when it is determined in the step (a) that another defect area exists in the data area, or that a normal defect area exists among the N number of defect areas, updating the P number of latest defect entries into P' number of latest defect entries, where P' is an integer satisfying $P' \geq 0$ where $P = P'$ or $P \neq P'$; and updating the latest defect entry number from P to P';

(c) incrementing, by one, each of the first latest update times information and the second latest update times information, and

(d) recording the latest defect list updated in the steps (b) and (c) in the defect management area.

30. A recording method to claim 29, wherein the step (d) includes the step of recording the updated latest defect list in the defect management area in the order of the updated latest header, the updated P' number of latest defect entries, and the updated latest anchor, or in the order of the updated latest anchor, the updated P' number of latest defect entries, and the updated latest header.

31. A recording method according to claim 30, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the method further comprises the step of executing the step (d) for the another defect management area.

32. A recording method according to claim 29, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein the method further comprises the step of executing the step (d) for the another defect management area.

33. A reproduction apparatus for reproducing information recorded on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list; the header, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes second update times information representing the number of times which the defect list has been updated;

the reproduction apparatus comprising:

a reproduction section for reproducing the information recorded on the information recording medium,

a storage section for storing the reproduced information, and

a control section for controlling execution of defect management processing which is performed using the reproduction section and the storage section, the control section having an inherent defect list identifier for identifying the defect list;

wherein:

the defect management processing includes the steps of:

(a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the

header, and determining whether or not a content of the inherent defect list identifier matches a content of the reproduced defect list identifier,

(b) reproducing the second update times information included in the anchor and determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier, and

(c) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (b) that the content of the first update times information matches the content of the second update times information.

34. A reproduction apparatus according to claim 33, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein:

the control section controls execution of the defect management processing for the another defect management area; and

the step (c) includes the steps of:

(c_1) performing the steps (a) and (b) for the another defect management area, and

(c_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

35. A reproduction method for reproducing information recorded on an information recording medium, wherein the information recording medium includes a data area for recording user data, and a defect management area for recording a defect list for managing N number of defect areas existing in the data area, where N is an integer satisfying $N \geq 0$; wherein: the defect list includes a header located at a fixed position in the defect list, N number of defect entries respectively including position information on positions of the N number of defect areas, and an anchor located at a fixed position in the defect list; the header, the N number of defect entries, and the anchor are located in this order in the defect list; the header includes a defect list identifier for identifying the defect list, first update times information representing the number of times which the defect list has been updated, and a defect entry number representing the number of the N number of defect entries; and the anchor includes second update times information representing the number of times which the defect list has been updated;

the reproduction method comprising the steps of:

(a) reproducing the defect list identifier, the defect entry number, and the first update times information which are included in the header, and determining whether or not a content of an inherent defect list identifier for identifying the defect list matches a content of the reproduced defect list identifier,

(b) reproducing the second update times information included in the anchor and determining whether or not a content of the first update times information matches a content of the second update times information when it is determined in the step (a) that the content of the inherent defect list identifier matches the content of the reproduced defect list identifier, and

(c) specifying the defect list recorded in the defect management area as the latest defect list when it is determined in the step (b) that the content of the first update times information matches the content of the second update times information.

36. A reproduction method according to claim 35, wherein the information recording medium further includes another defect management area for recording a defect list having a content identical to that of the defect list recorded in the defect management area,

wherein:

the step (c) includes the steps of:

(c_1) performing the steps (a) and (b) for the another defect management area, and

(c_2) specifying the defect list including the update times information having a largest number of updates as the latest defect list.

FIG. 1

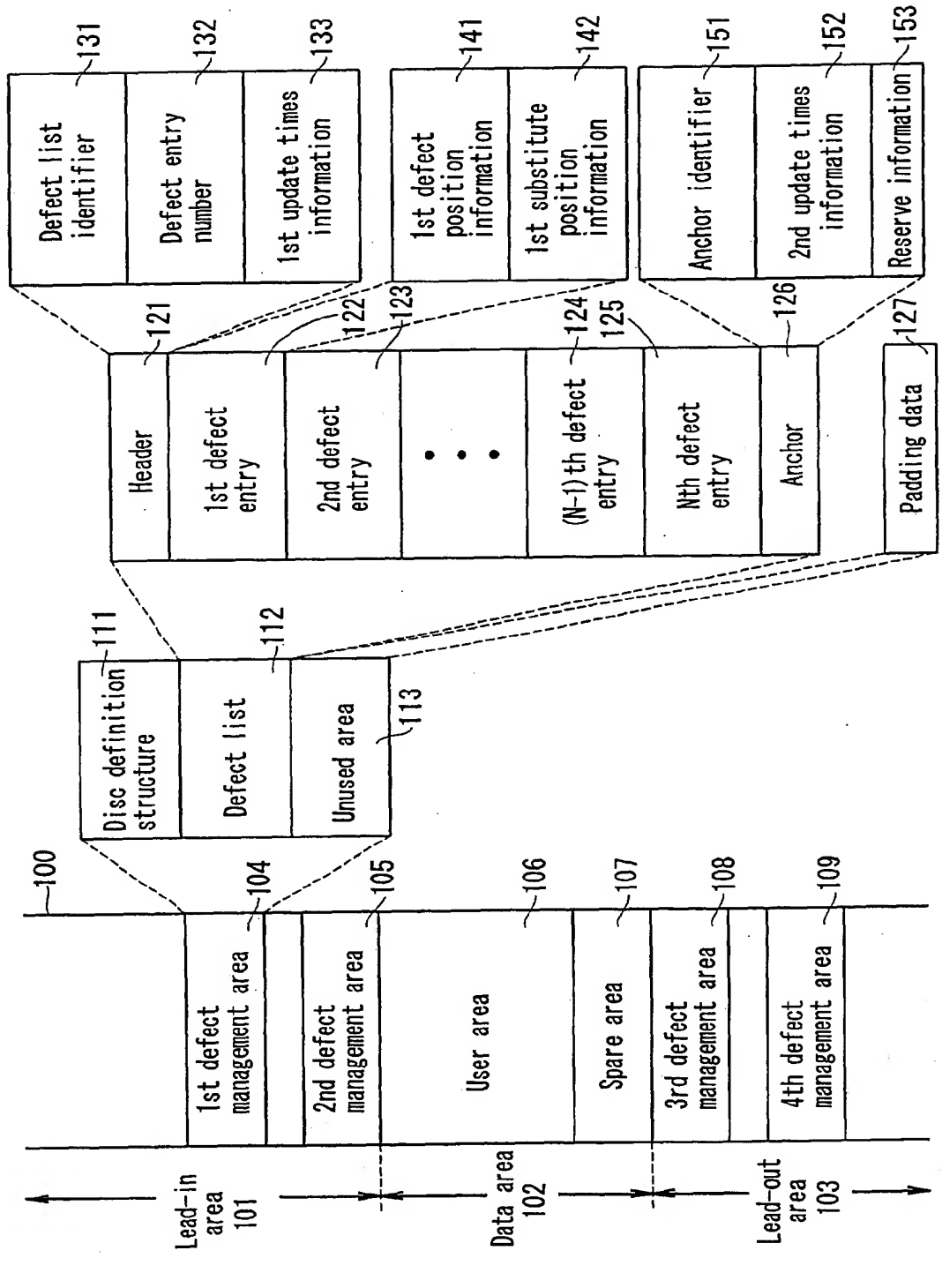

100
Lead-in area 101
Data area 102
Lead-out area 103
1st defect management area
2nd defect management area
User area
Spare area
3rd defect management area
4th defect management area
104
105
106
107
108
109
Disc definition structure
Defect list
Unused area
111
112
113
Header
1st defect entry
2nd defect entry
(N-1)th defect entry
Nth defect entry
Anchor
Padding data
121
122
123
124
125
126
127
Defect list identifier
Defect entry number
1st update times information
1st defect position information
1st substitute position information
Anchor identifier
2nd update times information
Reserve information
131
132
133
141
142
151
152
153

FIG. 2A

121 131 Header 132 133

	Defect list identifier (16 bits)	Defect entry number (16 bits)	1st update times information (32 bits)
BP	63 59 48	47 32	31 0
Val	0100 0000 0000 0000	• • • •	• • • •

FIG. 2B

122 141 1st defect entry 142

	1st defect position information (32 bits)	1st substitute position information (32 bits)
BP	63 59 48 47 32	31 0
Val	0000 0111 1111 1111 • • • 1111	• • • •

FIG. 2C

126 151 Anchor 153 152

	Anchor identifier (16 bits)	Reserve information (16 bits)	2nd update times information (32 bits)
BP	63 59 48	47 32	31 0
Val	1111 1111 1111 1111	• • • •	• • • •

FIG. 2D

113 Unused area 127

	Padding data
BP	63 59 0
Val	0000 0000 000 0000 • • • • • • • • 0000 0000 0000

FIG.3

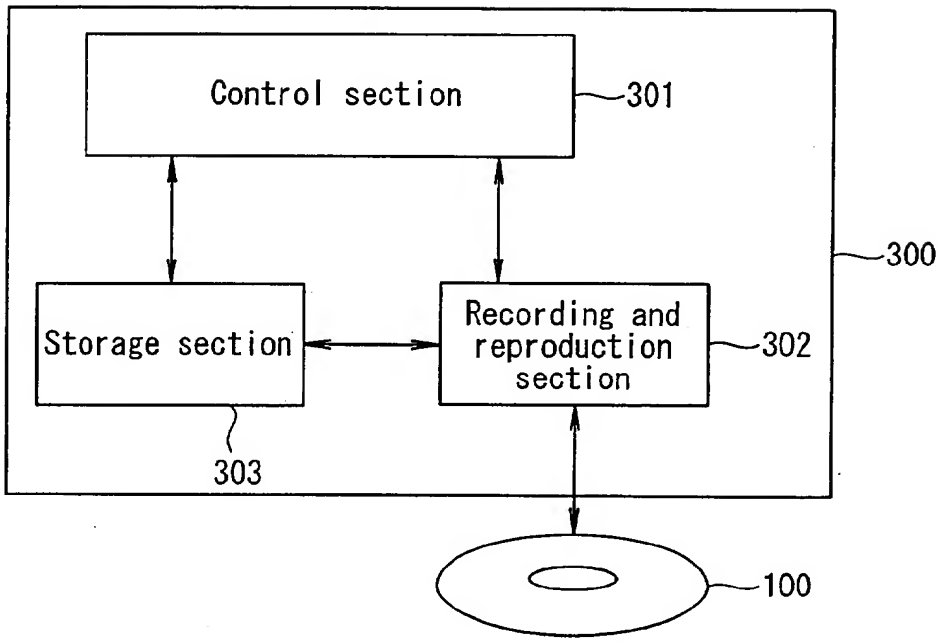

Control section
301
300
Storage section
Recording and reproduction section
302
303
100

FIG. 4

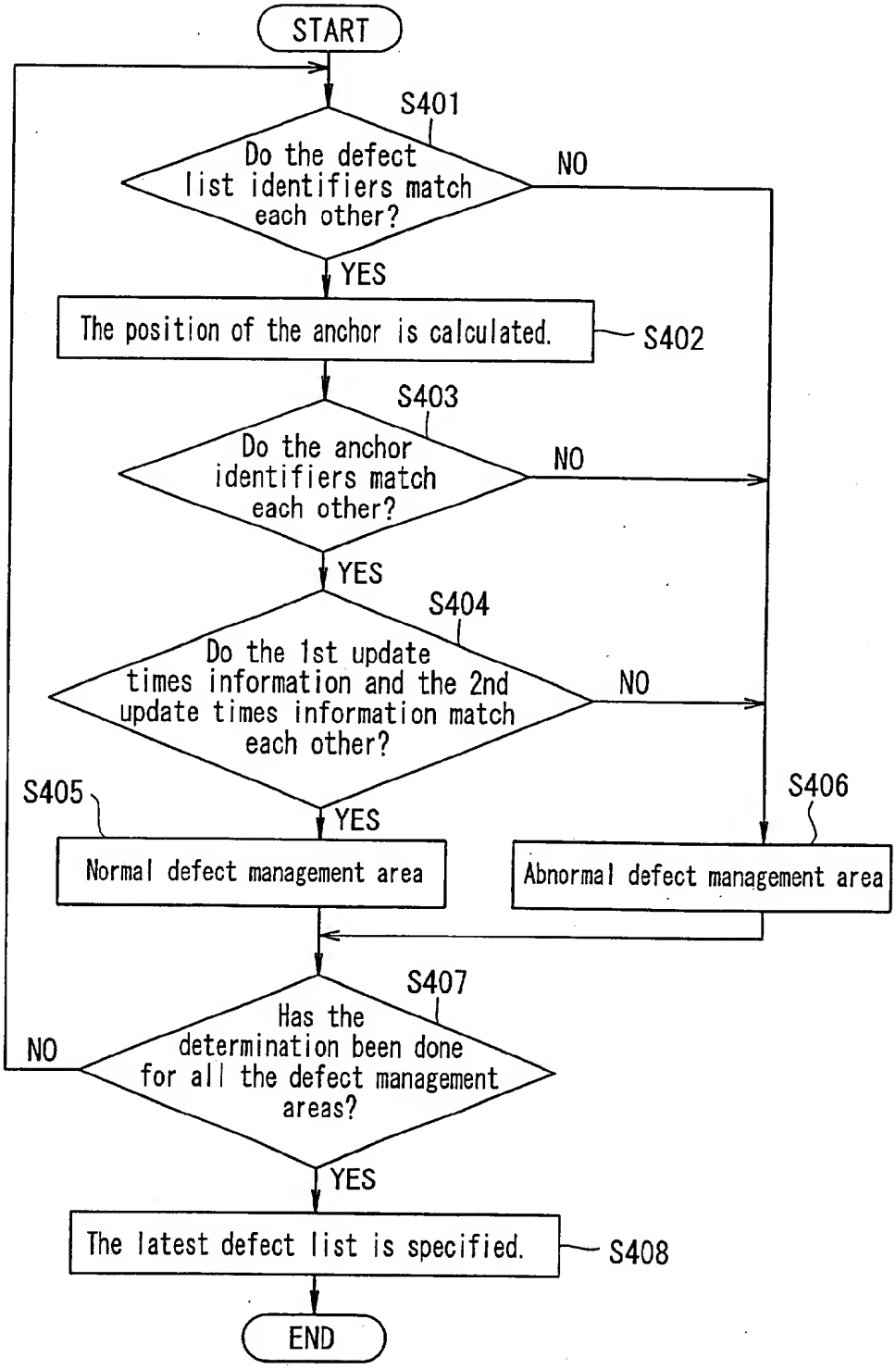

START
S401
Do the defect list identifiers match each other?
NO
YES
The position of the anchor is calculated.
S402
S403
Do the anchor identifiers match each other?
NO
YES
S404
Do the 1st update times information and the 2nd update times information match each other?
NO
YES
S405
Normal defect management area
S406
Abnormal defect management area
S407
Has the determination been done for all the defect management areas?
NO
YES
The latest defect list is specified.
S408
END

FIG. 5

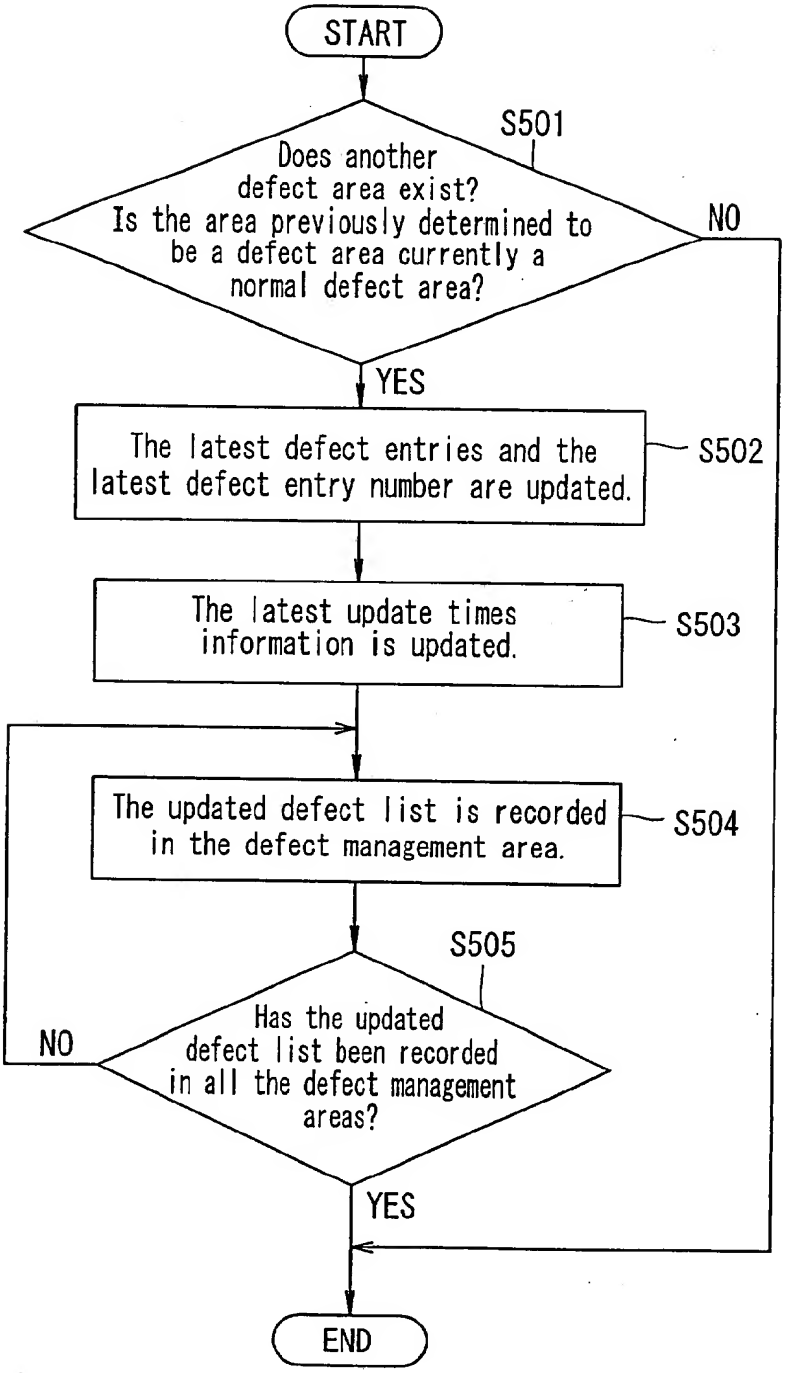

START
S501
Does another defect area exist? Is the area previously determined to be a defect area currently a normal defect area?
NO
YES
The latest defect entries and the latest defect entry number are updated.
S502
The latest update times information is updated.
S503
The updated defect list is recorded in the defect management area.
S504
S505
Has the updated defect list been recorded in all the defect management areas?
NO
YES
END

FIG. 6

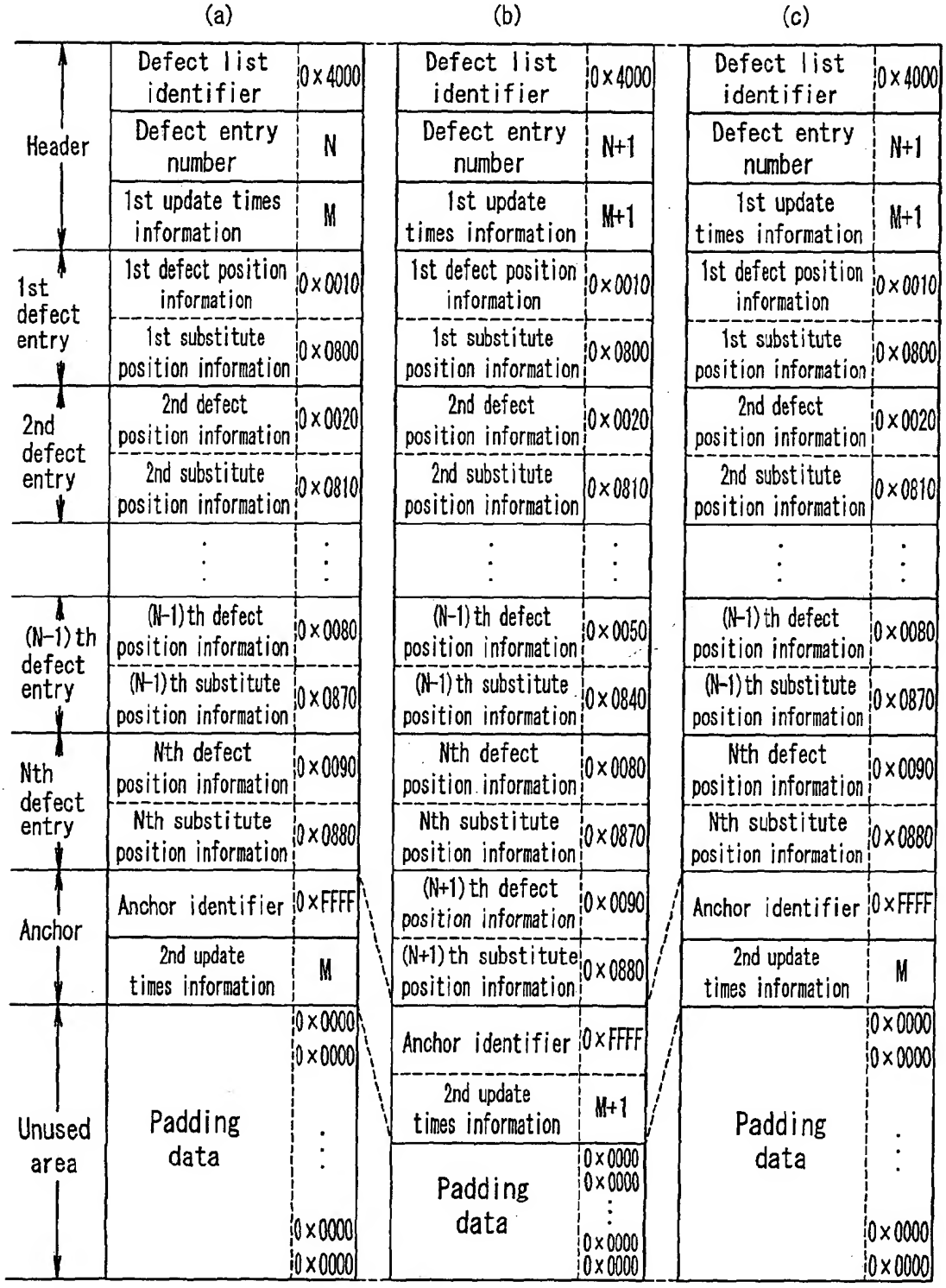

(a)
(b)
(c)
Header
1st defect entry
2nd defect entry
(N-1)th defect entry
Nth defect entry
Anchor
Unused area
Defect list identifier
0x4000
Defect entry number
N
N+1
1st update times information
M
M+1
1st defect position information
0x0010
1st substitute position information
0x0800
2nd defect position information
0x0020
2nd substitute position information
0x0810
(N-1)th defect position information
0x0080
0x0050
(N-1)th substitute position information
0x0870
0x0840
Nth defect position information
0x0090
0x0080
Nth substitute position information
0x0880
0x0870
Anchor identifier
0xFFFF
(N+1)th defect position information
0x0090
(N+1)th substitute position information
0x0880
2nd update times information
M
M+1
Padding data
0x0000

FIG. 7

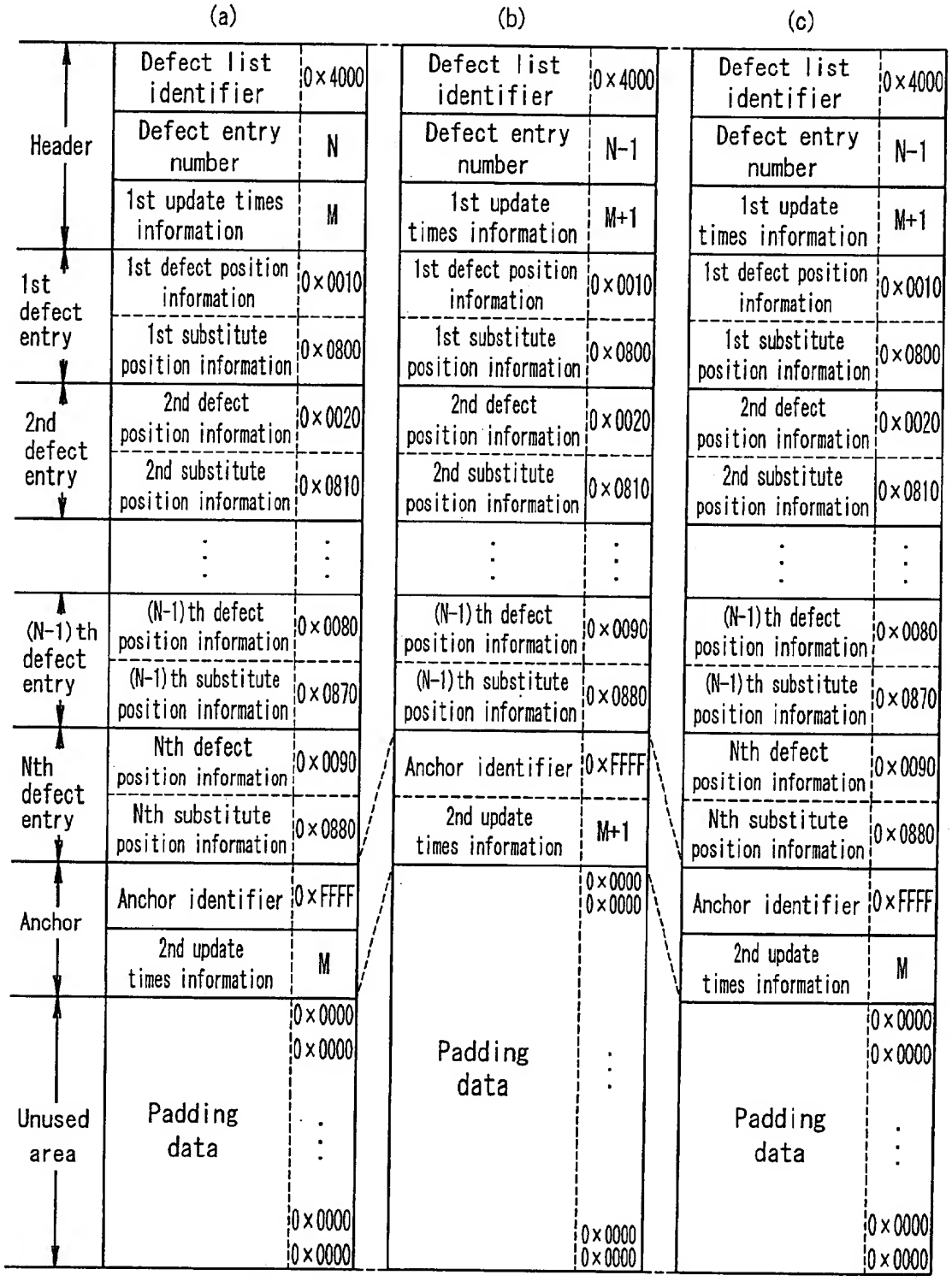

(a)
(b)
(c)
Header
1st defect entry
2nd defect entry
(N-1)th defect entry
Nth defect entry
Anchor
Unused area
Defect list identifier
Defect entry number
1st update times information
1st defect position information
1st substitute position information
2nd defect position information
2nd substitute position information
(N-1)th defect position information
(N-1)th substitute position information
Nth defect position information
Nth substitute position information
Anchor identifier
2nd update times information
Padding data
0x4000
N
M
0x0010
0x0800
0x0020
0x0810
0x0080
0x0870
0x0090
0x0880
0xFFFF
0x0000
N-1
M+1

FIG. 8

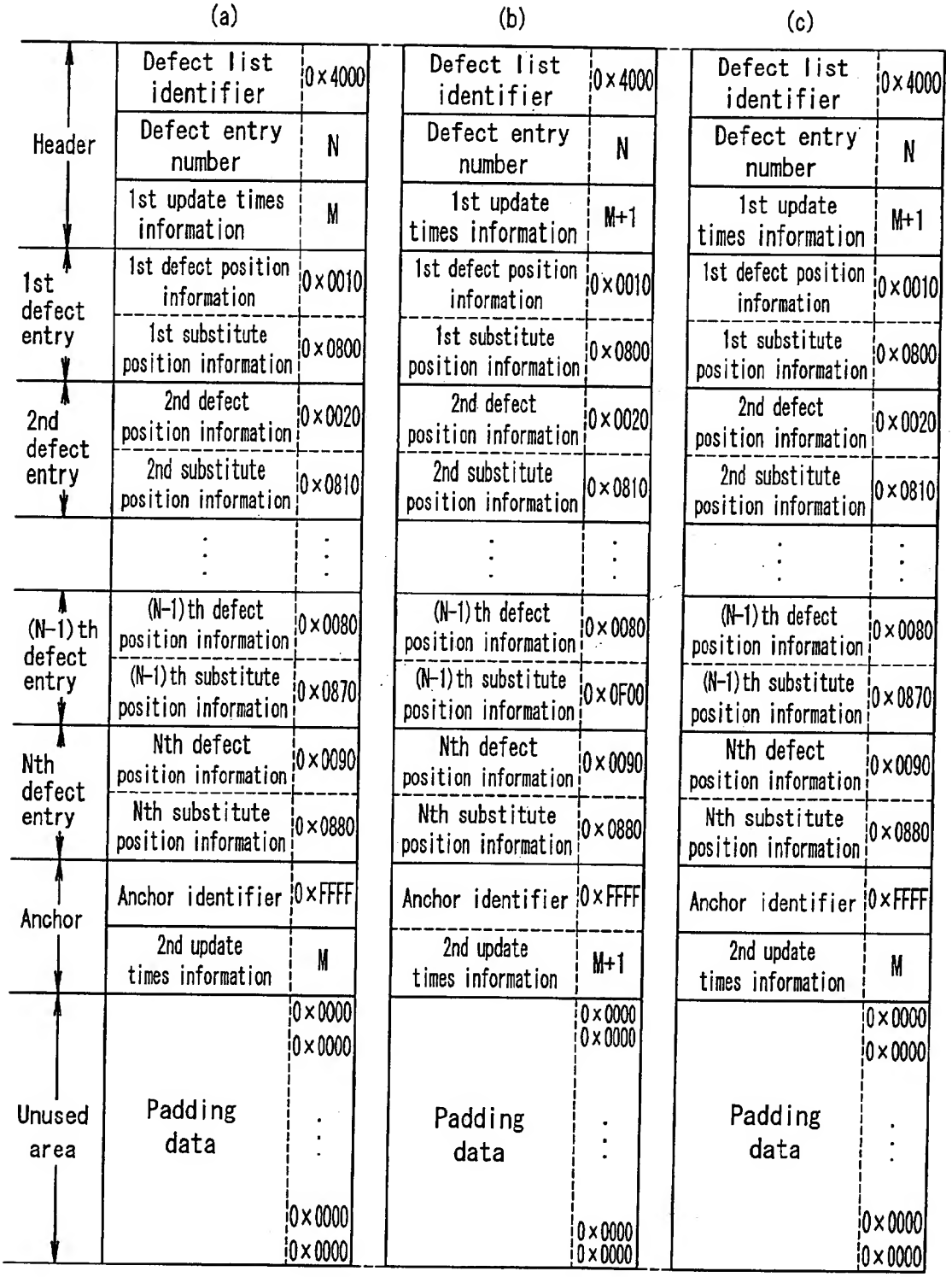

(a)
(b)
(c)
Header
1st defect entry
2nd defect entry
(N-1)th defect entry
Nth defect entry
Anchor
Unused area
Defect list identifier
0×4000
Defect entry number
N
1st update times information
M
M+1
1st defect position information
0×0010
1st substitute position information
0×0800
2nd defect position information
0×0020
2nd substitute position information
0×0810
(N-1)th defect position information
0×0080
(N-1)th substitute position information
0×0870
0×0F00
Nth defect position information
0×0090
Nth substitute position information
0×0880
Anchor identifier
0×FFFF
2nd update times information
Padding data
0×0000

FIG. 9

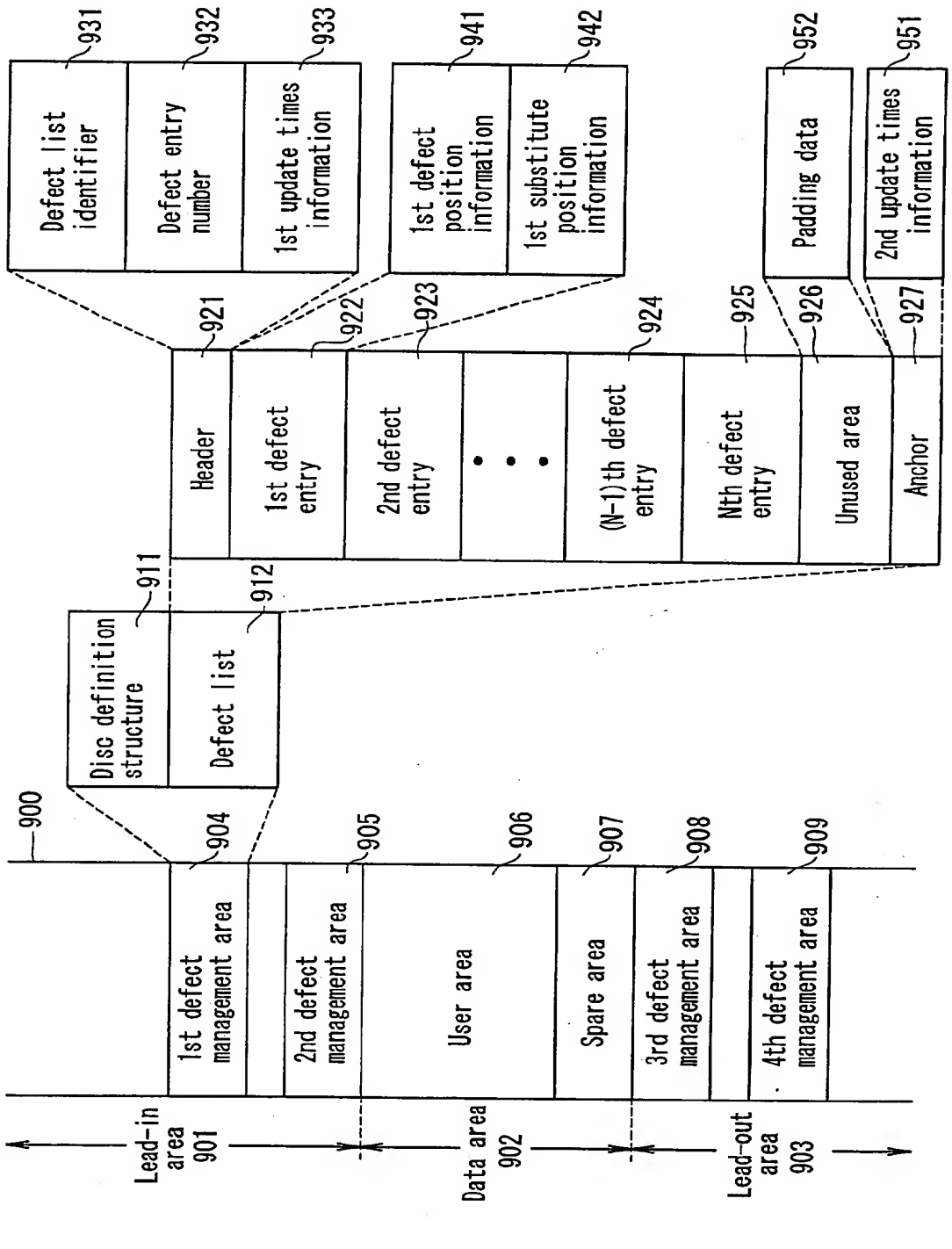

900
Disc definition structure
911
Defect list
912
Header
921
1st defect entry
922
2nd defect entry
923
(N-1)th defect entry
924
Nth defect entry
925
Unused area
926
Anchor
927
Defect list identifier
931
Defect entry number
932
1st update times information
933
1st defect position information
941
1st substitute position information
942
Padding data
952
2nd update times information
951
1st defect management area
904
2nd defect management area
905
User area
906
Spare area
907
3rd defect management area
908
4th defect management area
909
Lead-in area 901
Data area 902
Lead-out area 903

FIG. 10

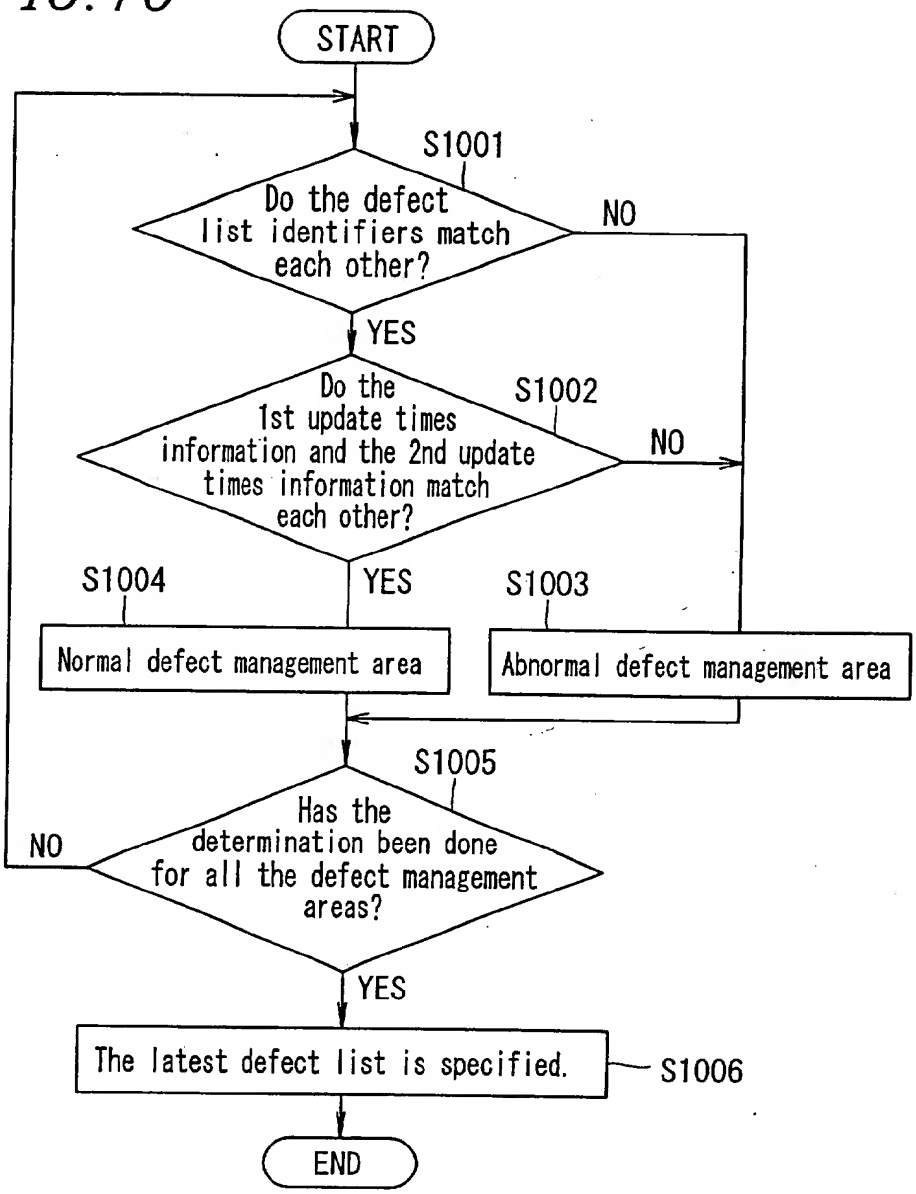

START
S1001
Do the defect list identifiers match each other?
NO
YES
Do the 1st update times information and the 2nd update times information match each other?
S1002
NO
YES
S1004
Normal defect management area
S1003
Abnormal defect management area
S1005
Has the determination been done for all the defect management areas?
NO
YES
The latest defect list is specified.
S1006
END

FIG. 11

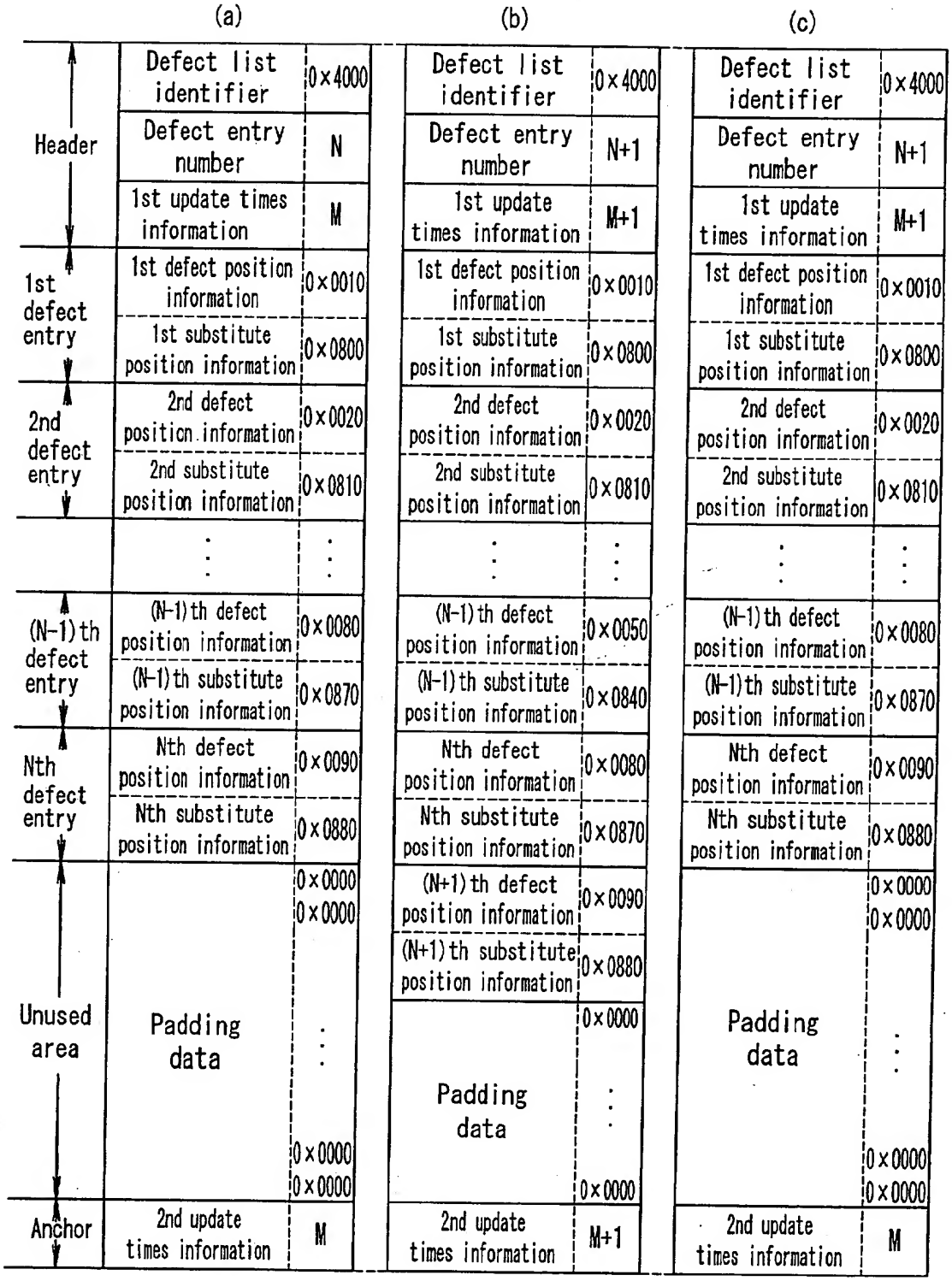

(a)
(b)
(c)
Header
1st defect entry
2nd defect entry
(N-1)th defect entry
Nth defect entry
Unused area
Anchor
Defect list identifier
Defect entry number
1st update times information
1st defect position information
1st substitute position information
2nd defect position information
2nd substitute position information
(N-1)th defect position information
(N-1)th substitute position information
Nth defect position information
Nth substitute position information
Padding data
2nd update times information
0x4000
N
M
0x0010
0x0800
0x0020
0x0810
0x0080
0x0870
0x0090
0x0880
0x0000
N+1
M+1
0x0050
0x0840
(N+1)th defect position information
(N+1)th substitute position information

FIG. 12

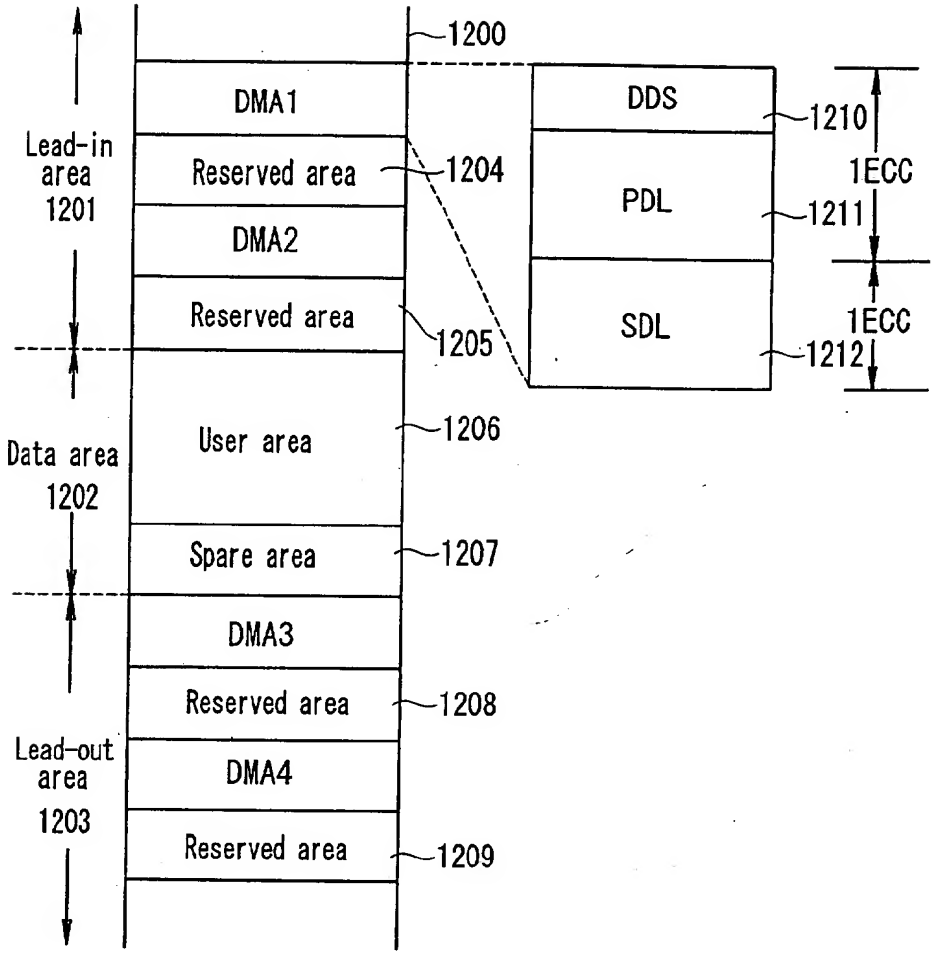

1200
DMA1
Reserved area
DMA2
Reserved area
User area
Spare area
DMA3
Reserved area
DMA4
Reserved area
Lead-in area 1201
Data area 1202
Lead-out area 1203
1204
1205
1206
1207
1208
1209
DDS
PDL
SDL
1210
1211
1212
1ECC
1ECC

FIG. 13

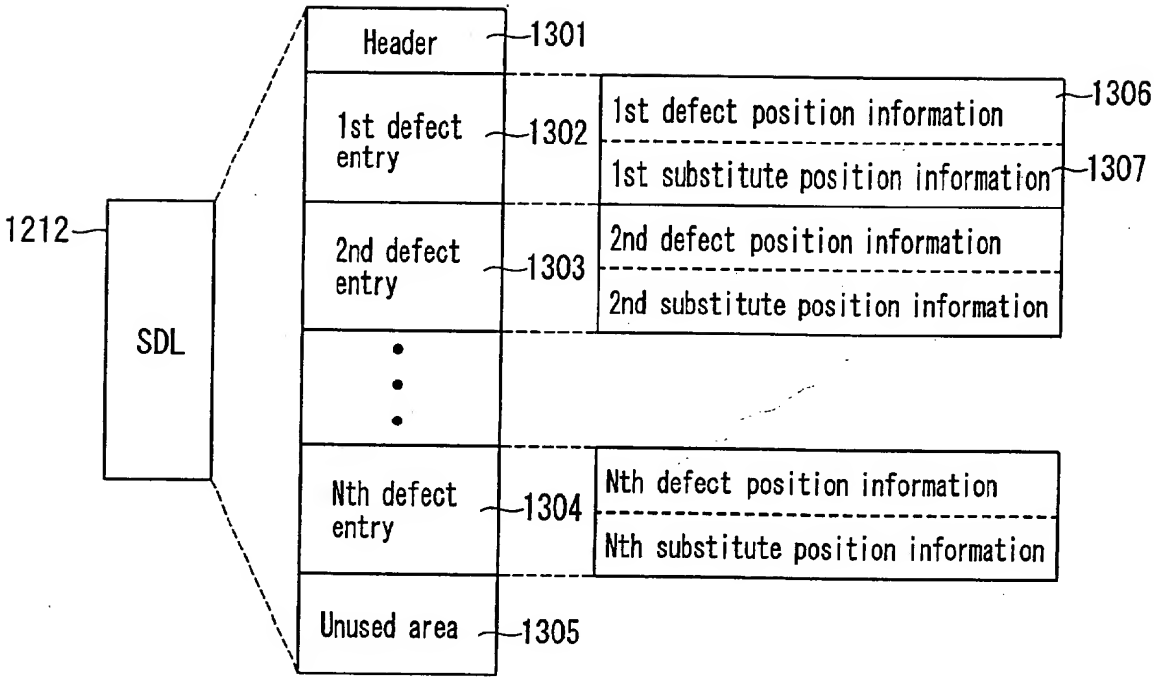

1212
SDL
Header
1301
1st defect entry
1302
1st defect position information
1306
1st substitute position information
1307
2nd defect entry
1303
2nd defect position information
2nd substitute position information
Nth defect entry
1304
Nth defect position information
Nth substitute position information
Unused area
1305

FIG. 14

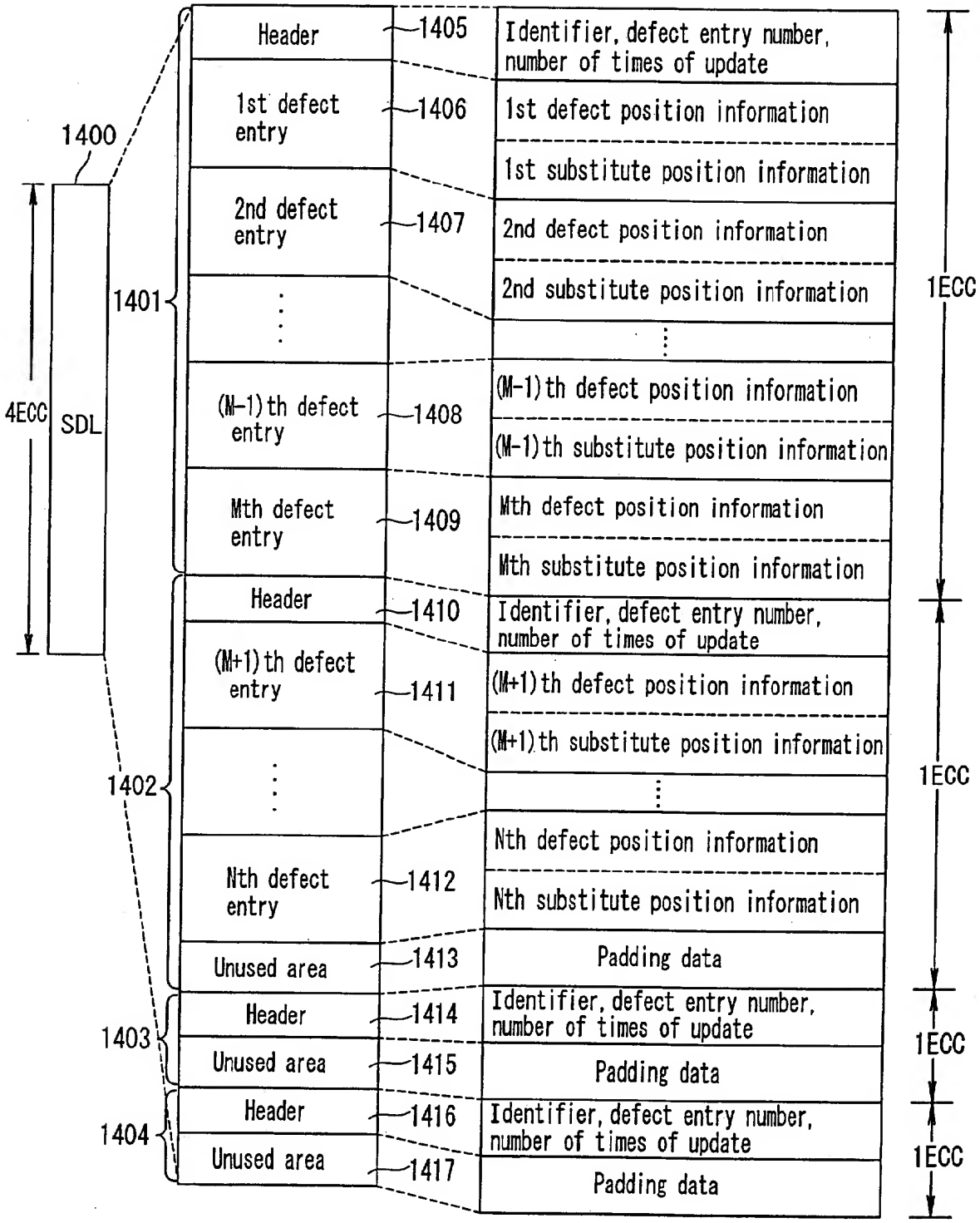

1400
4ECC
SDL
1401
1402
1403
1404
Header
1405
Identifier, defect entry number, number of times of update
1st defect entry
1406
1st defect position information
1st substitute position information
2nd defect entry
1407
2nd defect position information
2nd substitute position information
(M-1)th defect entry
1408
(M-1)th defect position information
(M-1)th substitute position information
Mth defect entry
1409
Mth defect position information
Mth substitute position information
1ECC
Header
1410
Identifier, defect entry number, number of times of update
(M+1)th defect entry
1411
(M+1)th defect position information
(M+1)th substitute position information
Nth defect entry
1412
Nth defect position information
Nth substitute position information
1ECC
Unused area
1413
Padding data
Header
1414
Identifier, defect entry number, number of times of update
1ECC
Unused area
1415
Padding data
Header
1416
Identifier, defect entry number, number of times of update
1ECC
Unused area
1417
Padding data

FIG. 15

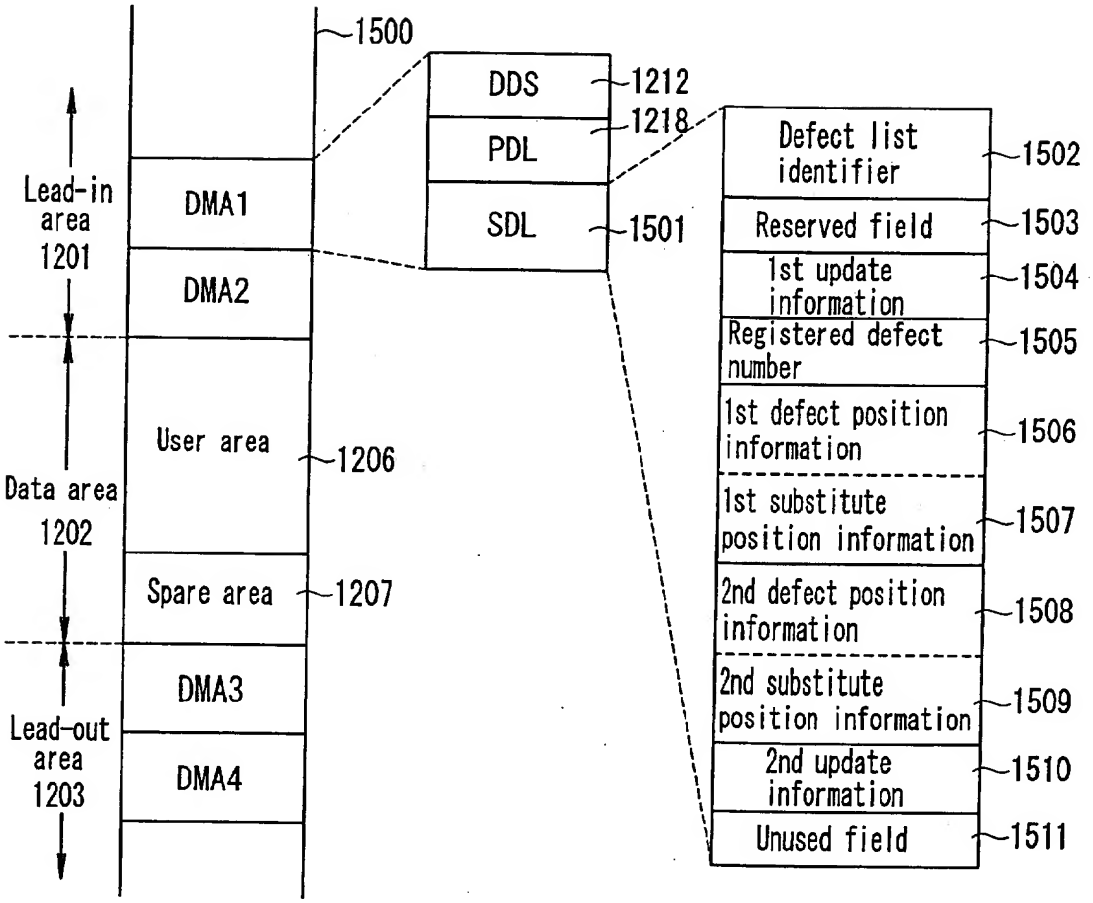
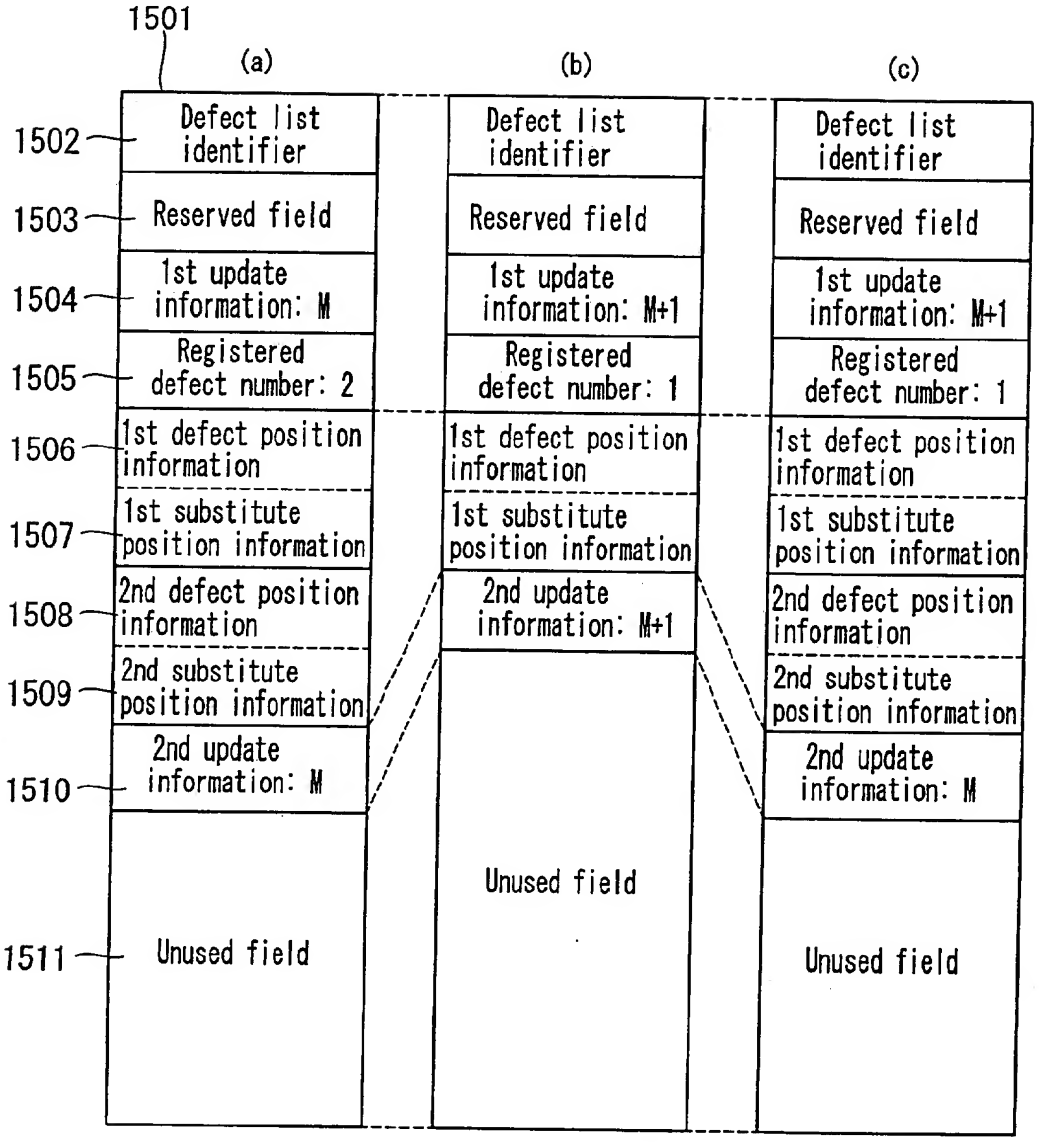

1500
DDS
1212
PDL
1218
SDL
1501
Lead-in area 1201
DMA1
DMA2
Data area 1202
User area
1206
Spare area
1207
Lead-out area 1203
DMA3
DMA4
Defect list identifier
1502
Reserved field
1503
1st update information
1504
Registered defect number
1505
1st defect position information
1506
1st substitute position information
1507
2nd defect position information
1508
2nd substitute position information
1509
2nd update information
1510
Unused field
1511

FIG. 16


1501
(a)
(b)
(c)
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
Defect list identifier
Reserved field
1st update information: M
Registered defect number: 2
1st defect position information
1st substitute position information
2nd defect position information
2nd substitute position information
2nd update information: M
Unused field
Defect list identifier
Reserved field
1st update information: M+1
Registered defect number: 1
1st defect position information
1st substitute position information
2nd update information: M+1
Unused field
Defect list identifier
Reserved field
1st update information: M+1
Registered defect number: 1
1st defect position information
1st substitute position information
2nd defect position information
2nd substitute position information
2nd update information: M
Unused field